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EFFICIENT MOTION VECTOR CODING FOR VIDEO COMPRESSION

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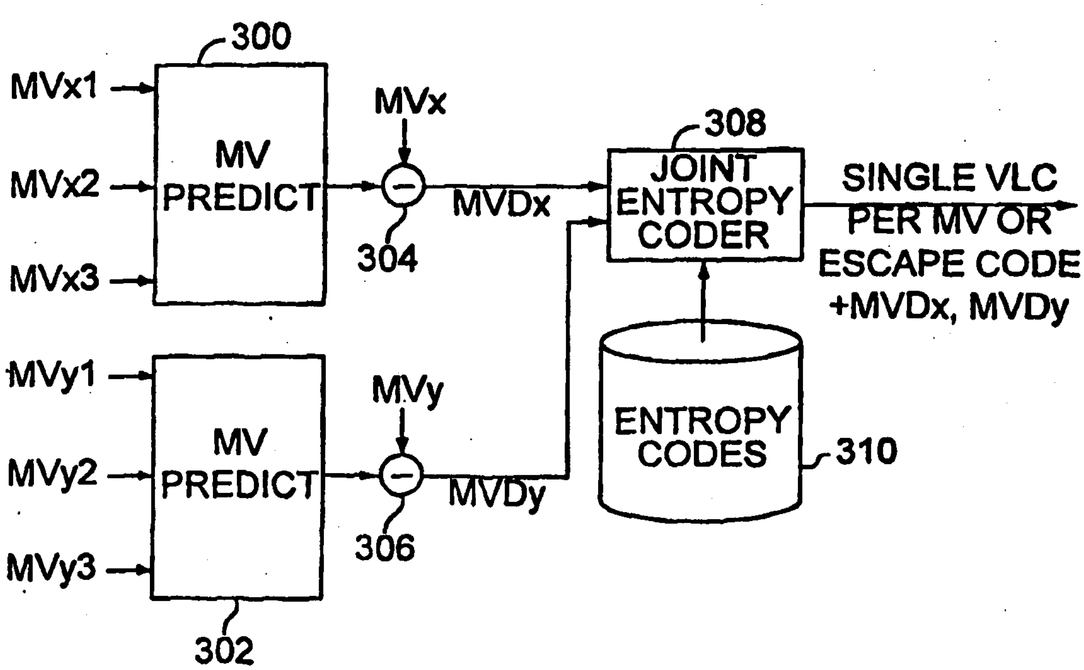

(57) Abstract

Video coding efficiency is improved by jointly coding the x and y components of motion vectors with a single variable length code. The motion vector components for a block of pixels are predicted based on motion vectors of neighboring blocks of pixels. The predicted x and y components are then jointly coded by assigning a single variable length code corresponding to the pair of components, rather than a separate code for each component. If the x and y components do not have a corresponding entry in the coding table, they are coded with an escape code followed by fixed length codes.

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EFFICIENT MOTION VECTOR CODING FOR VIDEO COMPRESSION

FIELD OF THE INVENTION

The invention relates to video coding, and specifically, to an improved method for coding motion vectors.

BACKGROUND OF THE INVENTION

Full-motion video displays based upon analog video signals have long been available in the form of television. With recent advances in computer processing capabilities and affordability, full-motion video displays based upon digital video signals are becoming more widely available. Digital video systems can provide significant improvements over conventional analog video systems in creating, modifying, transmitting, storing, and playing full-motion video sequences.

Digital video displays include large numbers of image frames that are played or rendered successively at frequencies of between 30 and 75 Hz. Each image frame is a still image formed from an array of pixels based on the display resolution of a particular system. As examples, VHS-based systems have display resolutions of 320x480 pixels, NTSC-based systems have display resolutions of 720x486 pixels, and high-definition television (HDTV) systems under development have display resolutions of 1360x1024 pixels.

The amounts of raw digital information included in video sequences are massive. Storage and transmission of these amounts of video information is infeasible with conventional personal computer equipment. Consider, for example, a digitized form of a relatively low resolution VHS image format having a 320x480 pixel resolution. A full-length motion picture of two hours in duration at this resolution corresponds to 100 gigabytes of digital video information. By comparison, conventional compact optical disks have capacities of about 0.6 gigabytes, magnetic hard disks have capacities of 1-2 gigabytes, and compact optical disks under development have capacities of up to 8 gigabytes.

To address the limitations in storing or transmitting such massive amounts of digital video information, various video compression standards or processes have been established, including MPEG-1, MPEG-2, and H.26X. These video compression techniques utilize similarities between successive image frames, referred to as temporal or interframe correlation, to provide interframe compression in which motion data and error signals are used to encode changes between frames.

In addition, the conventional video compression techniques utilize similarities within image frames, referred to as spatial or intraframe correlation, to provide

intraframe compression in which the image samples within an image frame are compressed. Intraframe compression is based upon conventional processes for compressing still images, such as discrete cosine transform (DCT) encoding. This type of coding is sometimes referred to as "texture" or "transform" coding. A "texture" generally refers to a two-dimensional array of image sample values, such as an array of chrominance and luminance values or an array of alpha (opacity) values. The term "transform" in this context refers to how the image samples are transformed into spatial frequency components during the coding process. This use of the term "transform" should be distinguished from a geometric transform used to estimate scene changes in some interframe compression methods.

Interframe compression typically utilizes motion estimation and compensation to encode scene changes between frames. Motion estimation is a process for estimating the motion of image samples (e.g., pixels) between frames. Using motion estimation, the encoder attempts to match blocks of pixels in one frame with corresponding pixels in another frame. After the most similar block is found in a given search area, the change in position of the pixel locations of the corresponding pixels is approximated and represented as motion data, such as a motion vector. Motion compensation is a process for determining a predicted image and computing the error between the predicted image and the original image. Using motion compensation, the encoder applies the motion data to an image and computes a predicted image. The difference between the predicted image and the input image is called the error signal. Since the error signal is just an array of values representing the difference between image sample values, it can be compressed using the same texture coding method as used for intraframe coding of image samples.

Although differing in specific implementations, the MPEG-1, MPEG-2, and H.26X video compression standards are similar in a number of respects. The following description of the MPEG-2 video compression standard is generally applicable to the others.

MPEG-2 provides interframe compression and intraframe compression based upon square blocks or arrays of pixels in video images. A video image is divided into image sample blocks called macroblocks having dimensions of 16 x 16 pixels. In MPEG-2, a macroblock comprises four luminance blocks (each block is 8 x 8 samples of luminance (Y)) and two chrominance blocks (one 8 x 8 sample block each for Cb and Cr).

In MPEG-2, interframe coding is performed on macroblocks. An MPEG-2 encoder performs motion estimation and compensation to compute motion vectors and block error signals. For each block M_N in an image frame N, a search is performed

across the image of a next successive video frame N+1 or immediately preceding image frame N-1 (i.e., bi-directionally) to identify the most similar respective blocks M_{N+1} or M_{N-1}. The location of the most similar block relative to the block M_N is encoded with a motion vector (DX,DY). The motion vector is then used to compute a block of predicted sample values. These predicted sample values are compared with block M_N to determine the block error signal. The error signal is compressed using a texture coding method such as discrete cosine transform (DCT) encoding.

Object-based video coding techniques have been proposed as an improvement to the conventional frame-based coding standards. In object-based coding, arbitrary shaped image features are separated from the frames in the video sequence using a method called "segmentation." The video objects or "segments" are coded independently. Object-based coding can improve the compression rate because it increases the interframe correlation between video objects in successive frames. It is also advantageous for variety of applications that require access to and tracking of objects in a video sequence.

In the object-based video coding methods proposed for the MPEG-4 standard, the shape, motion and texture of video objects are coded independently. The shape of an object is represented by a binary or alpha mask that defines the boundary of the arbitrary shaped object in a video frame. The motion of an object is similar to the motion data of MPEG-2, except that it applies to an arbitrary-shaped image of the object that has been segmented from a rectangular frame. Motion estimation and compensation is performed on blocks of a "video object plane" rather than the entire frame. The video object plane is the name for the shaped image of an object in a single frame.

The texture of a video object is the image sample information in a video object plane that falls within the object's shape. Texture coding of an object's image samples and error signals is performed using similar texture coding methods as in frame-based coding. For example, a segmented image can be fitted into a bounding rectangle formed of macroblocks. The rectangular image formed by the bounding rectangle can be compressed just like a rectangular frame, except that transparent macroblocks need not be coded. Partially transparent blocks are coded after filling in the portions of the block that fall outside the object's shape boundary with sample values in a technique called "padding."

In both frame-based and object-based video coding, the encoded bit stream typically includes many interframe-coded frames (P frames). Each of these P frames includes at least one motion vector per macroblock, and each motion vector includes X and Y components that coded independently. As such, motion vectors contribute a

significant amount of data for each coded P frame. There is a need, therefore, for more efficient motion vector coding schemes.

SUMMARY OF THE INVENTION

The invention provides an improved method of coding motion vectors for video coding applications. One aspect of the invention is a method for jointly coding a motion vector with a single entropy code. This method is based on the discovery that the probability of the X and Y components of the motion vector are not totally independent. To exploit the correlation between the motion vector components, the method uses entropy coding to assign a single variable length code to a joint parameter representing the combined X and Y components of the motion vector. Motion vector component pairs that are more likely are assigned a shorter length code, while less likely component pairs are assigned a longer length code or are coded with an escape code followed by a code for each component. This approach can be used in a variety of video coding applications, including both object-based and frame based coding. In addition, joint entropy coding of motion vectors can be used in combination with spatial prediction to code motion vectors more efficiently.

For example, in one implementation, an encoder first computes a predictor for the motion vector, and then computes differential X and Y components from the X and Y components of the vector currently being processed and its predictor. A joint entropy coder then computes a single variable length code for a joint parameter representing both the X and Y differential components.

The decoder performs the inverse of the encoder operations to reconstruct the motion vector from the variable length code. In particular, it computes the joint parameter from the variable length code, and then reconstructs the motion vector from the differential components and the components of the predictor.

Additional features of the invention will become more apparent from the following detailed description and accompany drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a video coder.

Fig. 2 is a block diagram of a video decoder.

Fig. 3 is a block diagram illustrating how an implementation of the invention jointly codes motion vector components for a macroblock with a single entropy code.

Fig. 4 is a diagram illustrating how a predictor for the motion vector of a current block is selected from motion vectors of neighboring macroblocks.

Fig. 5 is a diagram illustrating how a motion vector predictor is selected in cases where one or more neighboring macroblocks are outside the picture.

Fig. 6 is a block diagram illustrating how an implementation of the invention decodes a jointly coded motion vector.

Fig. 7 is a diagram of a computer system that serves as an operating environment for a software implementation of the invention.

DETAILED DESCRIPTION

Introduction

The first section below provides a description of a video encoder and decoder. Subsequent sections describe how to improve coding of motion vectors by exploiting the correlation between the X and Y components of the vectors.

This approach for jointly coding the X and Y components of a motion vector applies to both frame-based and object-based video coding. Both forms of video coding employ motion vectors to define the motion of a pixel or block of pixels from one frame to another. Typically, a motion vector is computed for regular sized blocks of pixels. In frame-based coding, the frame is divided into regular sized blocks. In object-based coding, each video object plane is divided into blocks. Since the object represented in a video object plane usually has a non-rectangular shape, object-based coders use the shape to determine which pixels in each block fall within the boundaries of the object. While frame-based and object-based coding differ in this respect, both approaches use motion vectors that define the motion of pixels in a block. Thus, the correlation between the X and Y components of motion vectors in both types of coders can be exploited to improve coding efficiency.

While the encoder and decoder described in the next section are object-based, they provide a sufficient basis for explaining how to implement the invention in both frame-based and object-based coding schemes.

Description of an Example Encoder and Decoder

Fig. 1 is a block diagram illustrating an implementation of an object-based video encoder. The input 30 to the encoder includes images representing the video objects in each frame, the shape of each video object and bounding rectangles. The shape information is available before the encoder codes texture or motion data. Frame-based coding differs in that the entire frame is coded without shape information, and the input 30 consists of a series of image frames.

The shape coding module 32 reads the definition of an object including its bounding rectangle and extends the bounding rectangle to integer multiples of

macroblocks. The shape information for an object comprises a mask or "alpha plane." The shape coding module 32 reads this mask and compresses it, using for example, a conventional chain coding method to encode the contour of the object.

Motion estimation module 34 reads an object including its bounding rectangle and a previously reconstructed image 36 and computes motion estimation data used to predict the motion of an object from one frame to another. The motion estimation module 34 searches for the most similar macroblock in the reconstructed image for each macroblock in the current image to compute a motion vector for each macroblock. The specific format of the motion vector from the motion estimation module 34 can vary depending on the motion estimation method used. In the implementation described below, there is a motion vector for each macroblock, which is consistent with current MPEG and H26X formats.

The motion compensation module 38 reads the motion vectors computed by the motion estimation module and the previously reconstructed image 36 and computes a predicted image for the current frame. Each pixel in the predicted image is constructed by using the motion vector for the macroblock that it resides in to find the corresponding pixel in the previously reconstructed image 36. The encoder then finds the difference between the image sample values in the input image block as specified in the input 30 and the corresponding sample values in the predicted image block as computed in the motion compensation module 38 to determine the error signal for the macroblock.

Texture coding module 40 compresses this error signal for inter-frame coded objects and compresses image sample values for the object from the input data stream 30 for intra-frame coded objects. The feedback path 42 from the texture coding module 40 represents the error signal. The encoder uses the error signal blocks along with the predicted image blocks from the motion compensation module to compute the previously reconstructed image 36.

The texture coding module 40 codes intra-frame and error signal data for an object using any of a variety of still image compression techniques. Example compression techniques include DCT, wavelet, as well as other conventional image compression methods.

The bit stream of the compressed video sequence includes the shape, motion and texture coded information from the shape coding, motion estimation, and texture coding modules. Multiplexer 44 combines and formats this data into the proper syntax and outputs it to the buffer 46. As explained in more detail below, the encoder also includes a motion vector encoder that uses entropy coding to jointly code the x and y components of the motion vector for each macroblock. The motion vector encoder

may be implemented as part of the motion estimation module 34 or as part of the data formatting functions in the multiplexer 44.

While the encoder can be implemented in hardware or software, it is most likely implemented in software. In a software implementation, the modules in the encoder represent software instructions stored in memory of a computer and executed in the processor, and the video data stored in memory. A software encoder can be stored and distributed on a variety of conventional computer readable media. In hardware implementations, the encoder modules are implemented in digital logic, preferably in an integrated circuit. Some of the encoder functions can be optimized in special-purpose digital logic devices in a computer peripheral to off-load the processing burden from a host computer.

Fig. 2 is a block diagram illustrating a decoder for an object-based video coding method. A demultiplexer 60 receives a bit stream representing a compressed video sequence and separates shapes, motion and texture encoded data on an object by object basis. The demultiplexer also includes a motion vector decoder that reconstructs the motion vector for each macroblock from a single variable length code.

Shape decoding module 64 decodes the shape or contour for the current object being processed. To accomplish this, it employs a shape decoder that implements the inverse of the shape encoding method used in the encoder of Fig. 1. The resulting shape data is a mask, such as a binary alpha plane or gray scale alpha plane representing the shape of the object.

The motion decoding module 66 decodes the motion information in the bit stream. The decoded motion information includes the motion vectors for each macroblock that are reconstructed from entropy codes in the incoming bitstream. The motion decoding module 66 provides this motion information to the motion compensation module 68, and the motion compensation module 68 uses the motion vectors to find predicted image samples in the previously reconstructed object data 70.

The texture decoding module 74 decodes error signals for inter-frame coded texture data and an array of color values for intra-frame texture data and passes this information to a module 72 for computing and accumulating the reconstructed image. For inter-frame coded objects, this module 72 applies the error signal data to the predicted image output from the motion compensation module to compute the reconstructed object for the current frame. For intra-frame coded objects the texture decoding module 74 decodes the image sample values for the object and places the reconstructed object in the reconstructed object module 72. Previously reconstructed objects are temporarily stored in object memory 70 and are used to construct the object for other frames.

Like the encoder, the decoder can be implemented in hardware, software or a combination of both. In software implementations, the modules in the decoder are software instructions stored in memory of a computer and executed by the processor, and video data stored in memory. A software decoder can be stored and distributed on a variety of conventional computer readable media. In hardware implementations, the decoder modules are implemented in digital logic, preferably in an integrated circuit. Some of the decoder functions can be optimized in special-purpose digital logic devices in a computer peripheral to off-load the processing burden from a host computer.

Improved Coding of Motion Vectors

The coding efficiency of motion vectors can be improved by exploiting the correlation between the X and Y components of a motion vector. Traditional coding methods code the X and Y components separately based on the premise that the probability distribution of the X and Y components are independent. We have discovered that the X and Y components are not totally independent, but instead, have a correlation.

To take advantage of this correlation, an implementation of the invention assigns a single entropy code to the joint X and Y components of a motion vector. Before coding, sample video data for a target bit rate and content scenario is used to generate a codebook. This codebook assigns a single variable length code to pairs of X and Y components based on their frequency of occurrence. More frequent, and therefore statistically more probable pairs, are assigned shorter length codes, while less frequent pairs are assigned longer length codes. A statistical analysis program computes the probability of each of the joint X and Y components by extracting the motion vector data generated from an encoder for several example video sequences that have the desired type of content. The program creates a probability distribution for pairs of motion vectors (namely, differential motion vectors) and then assigns codes to a subset of the motion vectors that are most probable.

To limit the size of the codebook, low probability pairs need not be assigned a code. Instead, these pairs can be coded by using an escape code to indicate that the motion vector components follow in fix length bit fields. Pairs are excluded from the codebook based on where they fall in the probability distribution.

While not required, the coding of motion vectors can be improved by using a differential coding process that takes advantage of the spatial dependency of motion vectors. In particular, a motion vector for a small block of pixels is likely to point in a similar direction as the motion vector for a neighboring block, especially if both the

current block and its neighbor are in a region of the frame having nearly uniform motion. One way to take advantage of this spatial dependency is to code the difference between a motion vector for the current block and the motion vector for a neighboring block, called the predictor. The implementation uses a form of spatial prediction to encode the X and Y components before assigning a joint entropy code.

Figure 3 is a block diagram illustrating how our implementation encodes motion vectors. The features shown in Fig. 3 are implemented in the encoder and operate on the motion vectors computed in the motion estimation block 34. First, the motion estimation block computes a motion vector for each macroblock in the frame. When a frame consists of more than one video object plane, the motion estimation block computes motion vectors for the macroblocks of each video object plane.

The encoder begins coding the motion vector for each macroblock by computing a predictor for the current motion vector. The implementation shown in Fig. 3 selects a predictor from among neighboring macroblocks. Figure 4 shows an example of the positioning of the candidates for the predictor relative to the current macroblock for which the motion vector is being encoded. In this example, the candidate macroblocks include the ones to the left 400, above 402, and above-right 404 relative to the current macroblock 406. The motion vectors for the candidate macroblocks are referred to as MV1, MV2, and MV3, respectively.

As shown in Fig. 3, the encoder computes the predictor separately for the X and Y components of the current macroblock. In particular, the motion vector predictors 300, 302 compute the median of the X and Y components for the candidate macroblocks. The median of these three values is chosen as the predictor for the X and Y components. The precise method of computing the predictor is not critical to the invention and other ways of selecting a predictor are possible. One alternative is to select a neighboring block located in the direction of the lowest gradient of the neighboring motion vectors. Another alternative is to compute an average of motion vectors of neighboring blocks.

Once the motion vector predictor selects the predictor, the encoder computes differential motion vector components. For each X and Y component, the encoder computes the difference between the component of the current motion vector and the corresponding component of the predictor. As reflected by subtractor units 304, 306 in Fig. 3, the X component of the predictor is subtracted from the X component of the current vector MVx, and the Y component of the predictor is subtracted from the Y component of the current vector MVy.

The resulting differential X and Y components (MVDx and MVDy) are then formed into a joint parameter that is coded with a single variable length code, or an

escape code followed by fixed code word for each differential component. The implementation uses a joint Huffman coding table that is trained for a target bit rate and video content. The joint entropy coder 308 looks up the joint parameter in the table to find a corresponding variable length code. If the coder finds a match in the table, it codes the joint parameter with a single variable length code. Otherwise, it codes an escape code followed by a fixed length code word for each component.

The entropy codes 310 shown in Fig. 3 refer to the Huffman coding table. An example of a Huffman coding table trained for low bit rate, talking head applications is set forth at the end of this section in Table 1. Following Table 1, Table 2 is an example of a Huffman table trained for more general video applications. While our implementation uses Huffman coding tables, the entropy codes can be computed using other forms of entropy coding such as arithmetic coding.

Since the predictor is selected from motion vectors of neighboring blocks of pixels, the encoder applies special rules to address the situation where one or more neighboring blocks are outside the picture. Figure 5 illustrates cases where a neighboring block is outside the picture and shows the motion vectors that are used to predict the motion vector in the current macroblock.

If one neighboring block is outside the picture (e.g., block 500 in Fig. 5), a zero motion vector (0,0) is used in its place. The predictor of the current macroblock 506 is computed as the median of the zero motion vector, and motion vectors MV2 and MV3 for the other two neighboring macroblocks 502, 504. As another example, the configuration on the far right of Fig. 5 shows the case where the above-right macroblock 524 is out of the picture. In this case, MV1 and MV2 for the other two macroblocks 520, 522 inside the picture are used along with the zero motion vector for the third macroblock 524 to predict the motion vector for the current macroblock 526.

If two candidate macroblocks 512, 514 are out of the picture (as shown in the middle diagram of Fig. 5), then the motion vector for the third neighboring macroblock 510 is selected as the predictor for the current macroblock 516.

Figure 6 is a diagram illustrating an implementation of a decoder for decoding a single variable length code representing joint motion vector components into X and Y motion vector components. The joint entropy decoder 600 reads the variable length code as input and finds the corresponding differential X and Y components in the entropy codes 602. In the current implementation, the entry codes are in the form of a Huffman table (e.g., tables 1 or 2 listed below). As noted above, the encoder can also use an alternative entropy coding scheme, in which case, the decoder would have the appropriate codebook to correspond with the codebook used in the encoder.

In some cases, the motion vector may be coded with an escape code followed by two fixed length codes representing the differential motion vector components. In this case, the joint entropy decoder 600 recognizes the escape code and interprets the following data as differential motion vectors instead of a variable length code. It then passes the differential X and Y components to the next stage.

Next, the decoder forms the motion vector from the differential motion vector components MVDx, MVDy and the X and Y components of the predictor. In particular the decoder adds each differential motion vector component MVDx, MVDy and the X and Y components of the predictor (see adders 604, 606, Fig. 6). The decoder computes the predictor components in the same way as the encoder. In particular, it has a motion vector predictor that computes the predictor of the motion vectors previously decoded for the three neighboring macroblocks (MVx1, MVy), (MVx2, MVy2) and (MVx3, MVy3). In the implementation, the motion vector predictor blocks 608, and 610 represent the computation of the median of the X and Y components, respectively, of the neighboring macroblocks. As noted above, other ways of computing the predictor are possible. Regardless of the specific form of prediction, the decoder performs inverse prediction according to the prediction scheme used in the encoder.

Once the motion vector for the current macroblock (MVx, MVy) is reconstructed, it is stored and used to decode the motion vector for neighboring macroblocks according to the prediction scheme.

The following tables provide examples of Huffman coding tables trained for talking head video (Table 1) and more general video content (Table 2).

Table 1: XY Joint VLC Motion Vector Table for Talking Head Video

Index	Mv x	Mv y	Number of bits	Code
0	0	0	1	1
1	0	-0.5	4	0011
2	-0.5	0	4	0101
3	0	0.5	4	0111
4	0.5	0	5	00010
5	-0.5	-0.5	5	01000
6	0.5	-0.5	5	01101
7	-0.5	0.5	6	000000
8	0.5	0.5	6	000001
9	0	1	6	011001
10	1	0	7	0000101
11	0	-1	7	0001111
12	-1	0	7	0010110
13	0	1.5	8	00001001
14	-0.5	1	8	00001101
15	1	-0.5	8	00001110
16	1.5	0	8	00011011

Index	Mv x	Mv y	Number of bits	Code
17	0	-1.5	8	00011101
18	1	0.5	8	00100001
19	0.5	-1	8	00100110
20	-1.5	0	8	00101000
21	0.5	1	8	00101010
22	-1	0.5	8	00101110
23	-1	-0.5	8	01001100
24	-0.5	-1	8	01001101
25	-0.5	1.5	9	000010001
26	1.5	-0.5	9	000110000
27	-1.5	-0.5	9	000110001
28	0.5	-1.5	9	000110011
29	1.5	0.5	9	000110101
30	0.5	1.5	9	001000000
31	1	-1	9	001001010
32	-0.5	-1.5	9	001001011
33	-1.5	0.5	9	001010010
34	-1	1	9	001011110
35	1	1	9	010010010
36	-1	-1	9	011000000
37	2	0	10	0000110011
38	-2	0	10	0000111111
39	0	2	10	0001101000
40	1	-1.5	10	0001110000
41	2.5	0	10	0001110001
42	-1	1.5	10	0010010000
43	-2.5	0	10	0010011100
44	0	-2	10	0010011101
45	-3.5	0	10	0010011111
46	3.5	0	10	0010101100
47	0	-2.5	10	0010101101
48	1	1.5	10	0100100010
49	0	2.5	10	0100100011
50	1.5	1	10	0100101000
51	1.5	-1.5	10	0100111001
52	1.5	-1	10	0100111011
53	-0.5	2	10	0110000011
54	1.5	1.5	10	0110000101
55	-1.5	1	10	0110000110
56	0	-3.5	10	0110001000
57	-1.5	-1	10	0110001001
58	-1	-1.5	10	0110001111
59	-1.5	1.5	11	00001000001
60	2.5	0.5	11	00001100001
61	-2.5	-0.5	11	00001100010
62	2	-0.5	11	00001111101
63	3	0	11	00011001000
64	2.5	-0.5	11	00011010011
65	0.5	-2	11	00011100100
66	0	3.5	11	00011100111
67	-0.5	-2	11	00100000100
68	-1.5	-1.5	11	00100000101
69	-0.5	2.5	11	00100100100
70	-2	-0.5	11	00100100101

Index	Mv x	Mv y	Number of bits	Code
71	2	0.5	11	00100111100
72	0.5	-2.5	11	00100111101
73	-1	2	11	00101001111
74	1	-2	11	00101111100
75	0.5	2	11	00101111101
76	0.5	2.5	11	00101111110
77	-2	0.5	11	01001000000
78	-2.5	0.5	11	01001001100
79	-3.5	-0.5	11	01001001111
80	-0.5	-2.5	11	01001010110
81	-3	0	11	01001011100
82	3.5	-0.5	11	01001110001
83	0	3	11	01001110100
84	0	-3	11	01100010110
85	-0.5	-3.5	11	01100010111
86	0.5	-3.5	11	01100011001
87	3.5	0.5	11	01100011100
88	-0.5	3.5	12	000010000100
89	3	-0.5	12	000010000101
90	-2	1	12	000010000111
91	2	-1	12	000011001000
92	-5.5	0	12	000011001001
93	-4.5	0	12	000011001010
94	5.5	0	12	000011001011
95	2	1	12	000011110001
96	1	2	12	000011110010
97	4.5	0	12	000011111000
98	-1	-2	12	000110010101
99	-3.5	0.5	12	000110100101
100	-2	-1	12	000111001101
101	-0.5	3	12	001000001101
102	-1	2.5	12	001001000111
103	1	-2.5	12	001001001101
104	3	0.5	12	001010011101
105	1.5	-2	12	001010111000
106	14.5	0	12	001010111110
107	1	2.5	12	010010011010
108	-2	1.5	12	010010011100
109	-1	3	12	010010100111
110	2.5	-1.5	12	010010101000
111	2.5	1	12	010010101011
112	1.5	-2.5	12	010010101110
113	-2.5	-1.5	12	010010101111
114	2	-1.5	12	010010110101
115	-14.5	0	12	010010110110
116	13.5	0	12	010010110111
117	3	1	12	010010111100
118	2.5	1.5	12	010010111110
119	0	-14.5	12	010010111111
120	-0.5	-3	12	010011100001
121	-1.5	2	12	010011111100
122	-3	-0.5	12	010011111101
123	0.5	3	12	010011111111
124	2.5	-1	12	011000001000

Index	Mv x	Mv y	Number of bits	Code
125	0.5	-3	12	011000001001
126	-2.5	1.5	12	011000001010
127	-2.5	1	12	011000001011
128	1.5	2.5	12	011000010000
129	1	-3	12	011000011100
130	1	-3.5	12	011000011110
131	4	0	12	011000011111
132	5	0	12	011000101010
133	0.5	3.5	12	011000101011
134	0	-4.5	12	011000110000
135	-1.5	2.5	12	011000110111
136	-14	0	12	011000111010
137	-13.5	0	13	0000100000000
138	-2	-1.5	13	0000100000001
139	-4	0	13	0000100001100
140	-3.5	-1.5	13	0000110000011
141	1.5	2	13	0000110001110
142	3.5	-1.5	13	0000111100000
143	3	-1	13	0000111100001
144	0	4.5	13	0000111101111
145	-4.5	-0.5	13	0000111110010
146	-2.5	-1	13	0000111110011
147	0	-5.5	13	0001100100101
148	-1	3.5	13	0001100100110
149	1.5	-3.5	13	0001100100111
150	-3	1	13	0001100101000
151	1	3	13	0001100101001
152	14	0	13	0001101001001
153	2	1.5	13	0001110010100
154	-1.5	3.5	13	0001110010101
155	-5	0	13	0001110011001
156	-3	0.5	13	0010000011000
157	4.5	0.5	13	0010010011000
158	-12.5	0	13	0010010011001
159	-1	-2.5	13	0010010011100
160	3	-1.5	13	0010010011110
161	-1	-3.5	13	0010010011111
162	2	-2	13	0010100110000
163	-1.5	-2.5	13	0010100110010
164	-1	-3	13	0010101110011
165	4.5	-0.5	13	0010101110100
166	-3	-1	13	0010101110101
167	-3.5	1.5	13	0010101111011
168	0	-4	13	0010101111111
169	1	-4	13	0010111111100
170	-4	-0.5	13	0100100001111
171	3.5	1	13	0100100110110
172	-15.5	0	13	0100101001010
173	-3.5	-1	13	0100101001011
174	3.5	1.5	13	0100101001100
175	0	4	13	0100101010010
176	-2	-2	13	0100101010011
177	-1.5	3	13	0100101010100
178	0	-13.5	13	0100101010101

Index	Mv x	Mv y	Number of bits	Code
179	3	1.5	13	0100101101000
180	-3	-1.5	13	0100101101001
181	2	2	13	0100101110101
182	-2	2	13	0100101110110
183	15.5	0	13	0100101110111
184	-2	3	13	0100101111011
185	3.5	-1	13	0100111000000
186	-4.5	0.5	13	0100111000001
187	-5.5	-0.5	13	0100111110110
188	-3	1.5	13	0100111110111
189	1.5	-3	13	0100111111100
190	-0.5	-4.5	13	0100111111101
191	1.5	3	13	0110000100110
192	12.5	0	13	0110000100111
193	-0.5	4.5	13	0110000111010
194	-1.5	-2	13	0110001010000
195	-1.5	-3.5	13	0110001010001
196	-2	2.5	13	0110001010010
197	-1	4	13	0110001010011
198	-2.5	2.5	13	0110001110110
199	1.5	3.5	14	00001000000100
200	-15	0	14	00001000000101
201	3	2	14	00001000000110
202	4	0.5	14	00001100000001
203	1	3.5	14	00001100000010
204	2.5	-3.5	14	00001100000011
205	-1.5	-3	14	00001100000100
206	3	-2	14	00001100000101
207	5.5	-0.5	14	00001100011000
208	-3	-2	14	00001100011001
209	0	5	14	00001100011010
210	0.5	-4.5	14	00001100011011
211	5	-0.5	14	00001100011110
212	-4	0.5	14	00001111011010
213	4	-0.5	14	00001111011011
214	-2	3.5	14	00001111011100
215	0	-15.5	14	00001111011101
216	0	13.5	14	00011001001000
217	0	-5	14	00011001001001
218	2	-2.5	14	00011001011110
219	0	-14	14	00011001011111
220	5.5	0.5	14	00011010010000
221	-3.5	1	14	00011010010001
222	-5.5	0.5	14	00011100101101
223	-0.5	-4	14	00011100101110
224	-1	4.5	14	00011100101111
225	-0.5	-14.5	14	00011100110000
226	4.5	1.5	14	00011100110001
227	-1.5	4.5	14	00100100011010
228	0.5	4.5	14	00100100011011
229	2.5	-2	14	00100100111010
230	-3	2	14	00100100111011
231	2.5	2	14	00101001100010
232	-2.5	-2	14	00101001110001

Index	Mv x	Mv y	Number of bits	Code
233	13.5	0.5	14	00101001110010
234	-4.5	1.5	14	00101001110011
235	0.5	-5.5	14	00101011100100
236	1.5	-4.5	14	00101011100101
237	-0.5	-5.5	14	00101011101101
238	-0.5	-5	14	00101011101110
239	2.5	2.5	14	00101011101111
240	3	-2.5	14	00101011110000
241	3.5	-2.5	14	00101011110001
242	0	5.5	14	00101011110010
243	-4.5	-1.5	14	00101011110011
244	0	14	14	00101011110100
245	-2.5	3.5	14	00101011110101
246	2.5	-2.5	14	00101011111100
247	2	-3.5	14	01001000010101
248	-0.5	13.5	14	01001000010110
249	4	1	14	01001000010111
250	-3.5	-2.5	14	01001000011000
251	-2.5	-2.5	14	01001000011001
252	3	-3	14	01001000011010
253	-0.5	4	14	01001000011011
254	2	2.5	14	01001000011100
255	-2	-2.5	14	01001000011101
256	-0.5	14.5	14	01001001101111
257	2	-3	14	01001001110100
258	-3.5	3.5	14	01001001110101
259	6.5	0.5	14	01001001110110
260	-14.5	-0.5	14	01001001110111
261	1	-5	14	01001010010000
262	3	2.5	14	01001010010001
263	3.5	-3.5	14	01001010010010
264	4	-1	14	01001010010011
265	3	-3.5	14	01001010011010
266	-1	-4	14	01001011001010
267	0	14.5	14	01001011001011
268	-6.5	-0.5	14	01001011001100
269	-4	1	14	01001011001101
270	-3.5	-3.5	14	01001011001110
271	-3	3	14	01001011001111
272	6.5	0	14	01001011101000
273	-6	0	14	01001011101001
274	-4	-1	14	01001011110100
275	0.5	-14.5	14	01001011110101
276	0.5	14.5	14	01001111011101
277	-0.5	5.5	14	01001111011110
278	4.5	-1.5	14	01001111011111
279	1	-4.5	14	01001111100000
280	3.5	-2	14	01001111100001
281	7.5	0	14	01001111100010
282	4	-2	14	01001111100011
283	13	0	14	01001111100100
284	13.5	-0.5	14	01001111100101
285	4.5	1	14	01001111100110
286	0.5	-13.5	14	01001111100111

Index	Mv x	Mv y	Number of bits	Code
287	-14.5	0.5	14	01001111101000
288	-7.5	0	14	01001111101001
289	14.5	0.5	14	01001111101010
290	5	0.5	14	01001111101011
291	-1	5	14	01100001000100
292	-3	2.5	14	01100001000101
293	-1.5	-4.5	14	01100001000110
294	2	3	14	01100001000111
295	14.5	-0.5	14	01100001001000
296	0.5	4	14	01100001001001
297	2.5	-3	14	01100001001010
298	15	0	14	01100001001011
299	-2	-3	14	01100001110110
300	-3.5	2.5	14	01100011011001
301	3	3	14	01100011011010
302	-3.5	2	14	01100011011011
303	3	-4	14	01100011101110
304	-7.5	-1.5	14	01100011101111
305	-4.5	-1	15	000010000001110
306	1	-6	15	000010000001111
307	0.5	-5	15	000010000110100
308	-5.5	-1.5	15	000010000110101
309	0.5	-4	15	000010000110110
310	8.5	0	15	000010000110111
311	-2.5	4.5	15	000011000000000
312	0	-15	15	000011000000001
313	-4.5	1	15	000011110101001
314	-2.5	-3.5	15	000011110101010
315	-5	0.5	15	000011110101011
316	-4	-1.5	15	000011110101100
317	-5	-0.5	15	000011110101101
318	3.5	3.5	15	000011110101110
319	5.5	1.5	15	000011110101111
320	-2.5	2	15	000011110110000
321	2.5	-4	15	000011110110001
322	-13	0	15	000011110110010
323	5	-1	15	000011110110011
324	7.5	0.5	15	000110010110000
325	-3	-2.5	15	000110010110001
326	-1	6	15	000110010110010
327	-0.5	14	15	000110010110011
328	4.5	-1	15	000110010110100
329	3.5	2	15	000110010110101
330	0.5	-6.5	15	000110010110110
331	-5	1	15	000110010110111
332	6.5	-0.5	15	000110010111000
333	2	-4	15	000110010111001
334	0	-8	15	000110010111010
335	6.5	1.5	15	000110010111011
336	-6.5	0	15	000111001011000
337	-5	3	15	001001000100100
338	-1	-5.5	15	001001000100101
339	-13.5	0.5	15	001001000100110
340	-13.5	-0.5	15	001001000100111

Index	Mv_x	Mv_y	Number of bits	Code
341	-7.5	-0.5	15	001001000101000
342	-1.5	-5.5	15	001001000101001
343	-5	1.5	15	001001000101010
344	-0.5	-13.5	15	001001000101011
345	-0.5	-7.5	15	001001000101100
346	5.5	-1.5	15	001001000101101
347	2.5	3	15	001001000101110
348	-2.5	3	15	001001000101111
349	0	-7	15	001001000110000
350	0	13	15	001001000110001
351	0	-6.5	15	001001000110010
352	0.5	5.5	15	001001000110011
353	1	4.5	15	001010011000110
354	5.5	-1	15	001010011000111
355	1.5	4.5	15	001010011001100
356	-1.5	5.5	15	001010011001101
357	-3	3.5	15	001010011001110
358	-5	-1.5	15	001010011001111
359	0	-12.5	15	001010011010000
360	-6.5	-1.5	15	001010011010001
361	0	-7.5	15	001010011010010
362	-3.5	-2	15	001010011010011
363	-0.5	-6.5	15	001010011010100
364	4.5	-2	15	001010011010101
365	8.5	-0.5	15	001010011010110
366	-2	-3.5	15	001010011010111
367	1	-6.5	15	001010011011000
368	-2	4	15	001010011011001
369	3.5	-3	15	001010011011010
370	1	-5.5	15	001010011011011
371	-6.5	0.5	15	001010011011100
372	2.5	3.5	15	001010011011101
373	3	-4.5	15	001010011011110
374	-1.5	4	15	001010011011111
375	-5.5	-1	15	001010011100000
376	2	3.5	15	001010011100001
377	5	1	15	001010111011000
378	-4	1.5	15	010010000011011
379	8	0	15	010010000011100
380	-8	0	15	010010000011101
381	-2	-4	15	010010000011110
382	8.5	0.5	15	010010000011111
383	-5	-1	15	010010000100000
384	1	4	15	010010000100001
385	-0.5	7.5	15	010010000100010
386	3	3.5	15	010010000100011
387	3.5	2.5	15	010010000100100
388	6	0	15	010010000100101
389	-10.5	0.5	15	010010000100110
390	1.5	-4	15	010010000100111
391	-1	-4.5	15	010010000101000
392	0.5	6.5	15	010010000101001
393	0.5	7.5	15	010010011011100
394	-4.5	-2.5	15	010010011011101

Index	Mv x	Mv y	Number of bits	Code
395	-2	-4.5	15	010010100110110
396	0.5	5	15	010010100110111
397	7	0	15	010010110000000
398	-8.5	0	15	010010110000001
399	-9.5	0.5	15	010010110000010
400	-4	2	15	010010110000011
401	4.5	2.5	15	010010110000100
402	-4	2.5	15	010010110000101
403	1	-7.5	15	010010110000110
404	1	-7	15	010010110000111
405	-1	-5	15	010010110001000
406	-3	4	15	010010110001001
407	-4	3	15	010010110001010
408	-9	0	15	010010110001011
409	14	-0.5	15	010010110001100
410	-5.5	1.5	15	010010110001101
411	-1.5	-4	15	010010110001110
412	3.5	-7.5	15	010010110001111
413	-4.5	-3.5	15	010010110010000
414	1.5	-7.5	15	010010110010001
415	2.5	-4.5	15	010010110010010
416	15.5	0.5	15	010010110010011
417	6.5	1	15	010011110100010
418	0.5	9.5	15	010011110100011
419	1	5	15	010011110100100
420	7.5	-0.5	15	010011110100101
421	4.5	2	15	010011110100110
422	-5	2	15	010011110100111
423	5	-1.5	15	010011110101000
424	1.5	-5.5	15	010011110101001
425	1.5	-5	15	010011110101010
426	-4.5	2.5	15	010011110101011
427	0	6	15	010011110101100
428	1.5	5.5	15	010011110101101
429	5.5	-3.5	15	010011110101110
430	0	7.5	15	010011110101111
431	-12.5	0.5	15	010011110110000
432	-0.5	6.5	15	010011110110001
433	4.5	-2.5	15	010011110110010
434	-6	-0.5	15	010011110110011
435	-0.5	13	15	010011110110100
436	-8	-0.5	15	010011110110101
437	-9.5	0	15	010011110110110
438	15.5	-0.5	15	010011110110111
439	-3.5	3	15	010011110111000
440	-1	5.5	15	010011110111001
441	0	-6	15	011000011101110
442	1.5	7.5	15	011000011101111
443	-1	6.5	15	011000110001000
444	-1	11	15	011000110001001
445	-0.5	-15.5	15	011000110001010
446	5	-3	15	011000110001011
447	7.5	1	15	011000110001100
448	3.5	3	15	011000110001101

Index	Mv x	Mv y	Number of bits	Code
449	3	-9	15	011000110001110
450	4	-5	15	011000110001111
451	4	-4	15	011000110100000
452	9.5	0.5	15	011000110100001
453	11.5	1	15	011000110100010
454	12	0	15	011000110100011
455	-7	0	15	011000110100100
456	-5.5	2.5	15	011000110100101
457	3.5	-5.5	15	011000110100110
458	3.5	-4.5	15	011000110100111
459	0.5	8.5	15	011000110101000
460	-7.5	1.5	15	011000110101001
461	4.5	-4.5	15	011000110101010
462	-4.5	-2	15	011000110101011
463	-4	3.5	15	011000110101100
464	5.5	3.5	15	011000110101101
465	-3.5	-4.5	15	011000110101110
466	-0.5	11.5	15	011000110101111
467	-6	0.5	15	011000110110000
468	-6.5	-1	15	011000110110001
469	6.5	-1	16	0000110001111100
470	-15.5	15.5	16	0000110001111101
471	1	-8	16	0000110001111110
472	-0.5	5	16	0000110001111111
473	-5	-2	16	0000111100110000
474	1.5	-9.5	16	0000111100110001
475	-8.5	0.5	16	0000111100110010
476	7	0.5	16	0000111100110011
477	7	1.5	16	0000111100110100
478	1.5	-6.5	16	0000111100110101
479	-0.5	7	16	0000111100110110
480	-2	5.5	16	0000111100110111
481	-1.5	-7.5	16	0000111100111000
482	-1.5	-6.5	16	0000111100111001
483	-4.5	2	16	0000111100111010
484	4.5	3.5	16	0000111100111011
485	-2.5	-4	16	0000111100111100
486	-9	-0.5	16	0000111100111101
487	10.5	0	16	0000111100111110
488	10.5	0.5	16	0000111100111111
489	-2.5	-3	16	0000111101000000
490	-4	-2	16	0000111101000001
491	0	15	16	0000111101000010
492	12.5	0.5	16	0000111101000011
493	0	15.5	16	0000111101000100
494	-7.5	0.5	16	0000111101000101
495	5	3.5	16	0000111101000110
496	2.5	-6.5	16	0000111101000111
497	-1.5	8.5	16	0000111101001000
498	0.5	-7.5	16	0000111101001001
499	-15.5	-0.5	16	0000111101001010
500	-3.5	5.5	16	0000111101001011
501	0	-9.5	16	0000111101001100
502	0	-8.5	16	0000111101001101

Index	Mv x	Mv y	Number of bits	Code
503	15.5	-1.5	16	0000111101001110
504	-3	-3.5	16	0000111101001111
505	4	1.5	16	0000111101010000
506	6	0.5	16	0000111101010001
507	2	-4.5	16	0001110010110010
508	-0.5	8.5	16	0001110010110011
509	3.5	4.5	16	0010000011001000
510	-6	-2	16	0010000011001001
511	-6	-1.5	16	0010000011001010
512	6	1	16	0010000011001011
513	-4.5	3	16	0010000011001100
514	0.5	-12.5	16	0010000011001101
515	1	14.5	16	0010000011001110
516	1.5	-10.5	16	0010000011001111
517	0.5	9	16	0010000011100000
518	0.5	-9.5	16	0010000011100001
519	-2	4.5	16	0010000011100010
520	4.5	-6.5	16	0010000011100011
521	-4.5	7.5	16	0010000011100100
522	4.5	-3.5	16	0010000011100101
523	4.5	-3	16	0010000011100110
524	-1.5	-8.5	16	0010000011100111
525	-3.5	5	16	0010000011101000
526	-3	4.5	16	0010000011101001
527	8.5	-1.5	16	0010000011101010
528	-1.5	6.5	16	0010000011101011
529	-4	-2.5	16	0010000011101100
530	2.5	-7.5	16	0010000011101101
531	8.5	1.5	16	0010000011101110
532	9	0	16	0010000011101111
533	9.5	-1.5	16	0010000011110000
534	9.5	0	16	0010000011110001
535	-3	-4	16	0010000011110010
536	3.5	-9.5	16	0010000011110011
537	-3.5	-3	16	0010000011110100
538	-3	-3	16	0010000011110101
539	-8.5	-0.5	16	0010000011110110
540	3.5	-4	16	0010000011110111
541	-7	0.5	16	0010000011111000
542	5	-2	16	0010000011111001
543	-7.5	-1	16	0010000011111010
544	-14	-0.5	16	0010000011111011
545	-0.5	-10.5	16	0010000011111100
546	0	6.5	16	0010000011111101
547	0	7	16	0010000011111110
548	14	0.5	16	0010000011111111
549	-15.5	0.5	16	0010010001000000
550	5	1.5	16	0010010001000001
551	0	12.5	16	0010010001000010
552	-16	0	16	0010010001000011
553	-10	0	16	0010010001000100
554	-6.5	1.5	16	0010010001000101
555	1.5	6.5	16	0010010001000110
556	-5.5	1	16	0010010001000111

Index	Mv x	Mv y	Number of bits	Code
557	4.5	-10.5	16	0010101110110010
558	-7.5	2.5	16	0010101110110011
559	-3	5	16	0010101111110100
560	-6	3.5	16	0010101111110101
561	6.5	2.5	16	0010101111110110
562	7	-0.5	16	0010101111110111
563	0	8.5	16	0010111111101000
564	2.5	-5.5	16	0010111111101001
565	-5	-2.5	16	0010111111101010
566	7.5	-1.5	16	0010111111101011
567	-1.5	7.5	16	0010111111101100
568	-0.5	10.5	16	0010111111101101
569	-2.5	4	16	0010111111101110
570	-1.5	9.5	16	0010111111101111
571	-1	-8	16	0010111111110000
572	-5.5	-3	16	0010111111110001
573	0.5	-15.5	16	0010111111110010
574	1.5	4	16	0010111111110011
575	-7	-1	16	0010111111110100
576	-3.5	4.5	16	0010111111110101
577	0.5	6	16	0010111111110110
578	9	1	16	0010111111110111
579	9.5	-3.5	16	0010111111111000
580	5	-2.5	16	0010111111111001
581	-15	-0.5	16	0010111111111010
582	-8.5	1.5	16	0010111111111011
583	9.5	1.5	16	0010111111111100
584	10.5	-0.5	16	0010111111111101
585	0.5	-8.5	16	0010111111111110
586	-3.5	8.5	16	0010111111111111
587	-1.5	-15.5	16	0100100000100000
588	11.5	1.5	16	0100100000100001
589	2.5	4	16	0100100000100010
590	3	-13.5	16	0100100000100011
591	0.5	13	16	0100100000100100
592	3	-5.5	16	0100100000100101
593	13.5	-1.5	16	0100100000100110
594	3	-5	16	0100100000100111
595	0.5	13.5	16	0100100000101000
596	3.5	6.5	16	0100100000101001
597	-9.5	-0.5	16	0100100000101010
598	0	-11.5	16	0100100000101011
599	4	-3	16	0100100000101100
600	14.5	-11.5	16	0100100000101101
601	14.5	-1.5	16	0100100000101110
602	0	-10.5	16	0100100000101111
603	-11.5	0	16	0100100000110000
604	6	-1	16	0100100000110001
605	-14.5	-14.5	16	0100100000110010
606	-0.5	-9.5	16	0100100000110011
607	-1.5	-6	16	0100100000110100
608	-3.5	-7	16	0100100000110101
609	-0.5	-6	16	0100111010100000
610	-2.5	-10.5	16	0100111010100001

Index	Mv x	Mv y	Number of bits	Code
611	-4.5	-14.5	16	0100111010100010
612	-11.5	-1.5	16	0100111010100011
613	-3.5	4	16	0100111010100100
614	-11.5	-0.5	16	0100111010100101
615	-1.5	10.5	16	0100111010100110
616	-6	-1	16	0100111010100111
617	-1	-7.5	16	0100111010101000
618	-1	-6	16	0100111010101001
619	5	2.5	16	0100111010101010
620	-7	-0.5	16	0100111010101011
621	-2	5	16	0100111010101100
622	-3.5	7.5	16	0100111010101101
623	-2	7.5	16	0100111010101110
624	-2	11	16	0100111010101111
625	-5.5	3	16	0100111010110000
626	-1.5	-11.5	16	0100111010110001
627	5.5	1	16	0100111010110010
628	-1.5	-9.5	16	0100111010110011
629	5.5	2.5	16	0100111010110100
630	-3	-5.5	16	0100111010110101
631	6	-3.5	16	0100111010110110
632	6	-2.5	16	0100111010110111
633	-5.5	5.5	16	0100111010111000
634	3	5	16	0100111010111001
635	-5.5	6.5	16	0100111010111010
636	-4	4	16	0100111010111011
637	6.5	-3.5	16	0100111010111100
638	6.5	-2.5	16	0100111010111101
639	1.5	7	16	0100111010111110
640	3.5	-5	16	0100111010111111
641	-5	-3.5	16	0100111100000000
642	1.5	10.5	16	0100111100000001
643	2	-6	16	0100111100000010
644	1	-15	16	0100111100000011
645	1	-9	16	0100111100000100
646	6.5	3.5	16	0100111100000101
647	1	-8.5	16	0100111100000110
648	-1.5	-5	16	0100111100000111
649	-0.5	6	16	0100111100001000
650	7	1	16	0100111100001001
651	-3.5	-5.5	16	0100111100001010
652	7	3	16	0100111100001011
653	-8	0.5	16	0100111100001100
654	-7.5	-2.5	16	0100111100001101
655	-0.5	8	16	0100111100001110
656	-6	1	16	0100111100001111
657	0	10	16	0100111100010000
658	7.5	1.5	16	0100111100010001
659	7.5	7.5	16	0100111100010010
660	7.5	8.5	16	0100111100010011
661	0	11	16	0100111100010100
662	8.5	-15	16	0100111100010101
663	8.5	-9.5	16	0100111100010110
664	8.5	-4.5	16	0100111100010111

Index	Mv x	Mv y	Number of bits	Code
665	-0.5	10	16	0100111100011000
666	-15.5	-1.5	16	0100111100011001
667	-2.5	6.5	16	0100111100011010
668	-2	-5	16	0100111100011011
669	3.5	8.5	16	0100111100011100
670	3.5	11	16	0100111100011101
671	-5.5	-5.5	16	0100111100011110
672	2	4	16	0100111100011111
673	-4.5	5	16	0100111100100000
674	9.5	-0.5	16	0100111100100001
675	-15	-1	16	0100111100100010
676	4	-1.5	16	0100111100100011
677	9.5	1	16	0100111100100100
678	0	-16	16	0100111100100101
679	10.5	-3.5	16	0100111100100110
680	-4	-4.5	16	0100111100100111
681	-1	9.5	16	0100111100101000
682	-4	-4	16	0100111100101001
683	-1	13.5	16	0100111100101010
684	-5.5	-2	16	0100111100101011
685	4	3	16	0100111100101100
686	12.5	-1.5	16	0100111100101101
687	12.5	-0.5	16	0100111100101110
688	-0.5	-15	16	0100111100101111
689	4.5	-9.5	16	0100111100110000
690	13	-0.5	16	0100111100110001
691	0	-12	16	0100111100110010
692	-10	-0.5	16	0100111100110011
693	-14	0.5	16	0100111100110100
694	0	-10	16	0100111100110101
695	1	6.5	16	0100111100110110
696	13.5	4.5	16	0100111100110111
697	-0.5	-12.5	16	0100111100111000
698	0	-9	16	0100111100111001
699	-9.5	-1	16	0100111100111010
700	-11.5	-3.5	16	0100111100111011
701	1.5	-7	16	0100111100111100
702	-3	5.5	16	0100111100111101
703	1.5	-6	16	0100111100111110
704	2.5	5.5	16	0100111100111111
705	14.5	1.5	16	0100111101000000
706	2.5	6	16	0100111101000001
707	15.5	-15.5	16	0100111101000010
708	-3	8.5	16	0100111101000011
709	ESC	ESC	7	0010001

Table 2: XY Joint VLC Motion Vector Table for General Video

Index	Mv x	Mv y	Number of bits	Code
0	0	0	1	0
1	-0.5	0	5	10011
2	0	-0.5	5	10101
3	0.5	0	5	11001
4	-0.5	-0.5	5	11011
5	0	0.5	6	100100
6	0.5	-0.5	6	111000
7	0.5	0.5	6	111001
8	-0.5	0.5	6	111101
9	1	0	7	1011101
10	-1	0	7	1101000
11	0	-1	7	1110110
12	0	1	8	10010111
13	1	-0.5	8	10111101
14	-1	-0.5	8	11000111
15	1.5	0	8	11010110
16	-1	0.5	8	11101010
17	-0.5	-1	8	11101110
18	0.5	-1	8	11110000
19	-1.5	0	8	11110001
20	1	0.5	8	11111010
21	0	-1.5	9	100101010
22	0.5	1	9	100101100
23	-0.5	1	9	101000000
24	-1	-1	9	101001000
25	0	1.5	9	101100010
26	1	-1	9	101101001
27	-0.5	-1.5	9	101111100
28	-1.5	-0.5	9	101111110
29	2	0	9	110000001
30	1.5	-0.5	9	110000011
31	-1	1	9	110001010
32	0.5	-1.5	9	110001100
33	-2	0	9	110001101
34	1	1	9	110100110
35	0	-2	9	110101001
36	1.5	0.5	9	111100110
37	-1.5	0.5	9	111110000
38	-0.5	1.5	9	111110110
39	0.5	1.5	10	1001010011
40	0	2	10	1010001010
41	-2.5	0	10	1010010011
42	0	-2.5	10	1010010111
43	2.5	0	10	1010011100
44	0	-3.5	10	1011010100
45	0	2.5	10	1011010111
46	-2	-0.5	10	1011100000
47	2	-0.5	10	1011100111
48	-1	-1.5	10	1011111111
49	3	0	10	1100000000
50	-1.5	-1	10	1100001010
51	-0.5	-2	10	1100001100
52	0	3.5	10	1100001110

Index	Mv x	Mv y	Number of bits	Code
53	0	-3	10	1100010000
54	1.5	-1	10	1100010011
55	-3	0	10	1101001011
56	-1	-2	10	1101010000
57	0	3	10	1101011100
58	0.5	-2	10	1101011111
59	-2.5	-0.5	10	1110100110
60	-2	0.5	10	1110101100
61	1	-1.5	10	1110101110
62	-2	-1	10	1110101111
63	2	0.5	10	1110111101
64	-1.5	1	10	1110111111
65	-0.5	-2.5	10	1111100100
66	2	-1	10	1111100110
67	-3.5	0	10	1111101111
68	-0.5	2	10	1111110010
69	3.5	0	10	1111110100
70	1	-2	10	1111110111
71	1.5	1	10	1111111011
72	-2.5	0.5	10	1111111110
73	-1.5	-1.5	11	10010100100
74	-6.5	0	11	10010110101
75	0.5	-2.5	11	10010110111
76	-0.5	-3.5	11	10100001000
77	1.5	-1.5	11	10100001100
78	-0.5	2.5	11	10100001101
79	2.5	-0.5	11	10100010001
80	6.5	0	11	10100010111
81	2.5	0.5	11	10100011001
82	0.5	2.5	11	10100100101
83	-1	1.5	11	10100101010
84	-2	1	11	10100101100
85	0	-6.5	11	10100110000
86	0	-4	11	10100110110
87	1.5	1.5	11	10100111101
88	1	1.5	11	10100111110
89	-3.5	-0.5	11	10100111111
90	-1.5	1.5	11	10110000101
91	-3.5	0.5	11	10110000110
92	0.5	-3.5	11	10110000111
93	0.5	2	11	10110001101
94	-5.5	0	11	10110010111
95	5.5	0	11	10110011001
96	-0.5	3.5	11	10110100000
97	-4	0	11	10110100001
98	-1	2	11	10110101011
99	3	-0.5	11	10110110101
100	-3	-0.5	11	10110111000
101	-0.5	-3	11	10110111010
102	2	1	11	10110111011
103	3.5	0.5	11	10110111100
104	-9.5	0	11	10110111110
105	3	-1	11	10111000010
106	3	0.5	11	10111001000

Index	Mv_x	Mv_y	Number of bits	Code
107	0.5	3.5	11	10111001100
108	-14.5	0	11	10111001101
109	9.5	0	11	10111100100
110	4	0	11	10111100110
111	9	0	11	10111110101
112	-0.5	3	11	11000000010
113	3.5	-0.5	11	11000001010
114	5	0	11	11000010000
115	6	0	11	11000010001
116	4.5	0	11	11000010011
117	0	-9.5	11	11000100010
118	-3	-1	11	11000100100
119	-4.5	0	11	11000100101
120	-6	0	11	11000101110
121	-1	-3	11	11010100010
122	14.5	0	11	11010101001
123	-15.5	0	11	11010101011
124	0	-4.5	11	11010101100
125	0	6.5	11	11010101111
126	-5	0	11	11101000010
127	0	-14.5	11	11101000101
128	1	2	11	11101000110
129	8.5	0	11	11101001001
130	-3.5	-1.5	11	11101001010
131	3	1	11	11101001011
132	-11.5	0	11	11101001111
133	0	5.5	11	11101111100
134	-2	-1.5	11	11110010001
135	0.5	-3	11	11110010011
136	-2	-2	11	11110010100
137	0	-15.5	11	11110010101
138	-15	0	11	11110010110
139	0	-6	11	11110010111
140	-8.5	0	11	11110011101
141	-9	0	11	11110011110
142	-3	0.5	11	11110011111
143	15.5	0	11	11111000101
144	0	4	11	11111000111
145	11.5	0	11	11111001111
146	-3.5	1.5	11	11111011101
147	0.5	3	11	11111100001
148	-7	0	11	11111100011
149	2.5	-1	11	11111100111
150	-6.5	-0.5	11	11111101010
151	0	-5.5	11	11111101100
152	-2.5	-1	11	11111110000
153	0	-5	11	11111110010
154	-1	3	11	11111110100
155	-3	1	11	11111111010
156	0	6	12	100101000001
157	2.5	-1.5	12	100101000110
158	0	-9	12	100101001010
159	-0.5	-6.5	12	100101011001
160	2	-2	12	100101011010

Index	Mv x	Mv y	Number of bits	Code
161	-1.5	-2	12	100101011111
162	0	4.5	12	100101101000
163	-4	-0.5	12	100101101001
164	-3.5	1	12	100101101101
165	-4	-1	12	101000001010
166	0	5	12	101000001101
167	-6.5	0.5	12	101000010010
168	1	-3	12	101000010101
169	-1	-4	12	101000011100
170	-16	0	12	101000011110
171	-1	-2.5	12	101000011111
172	-3.5	-1	12	101000100101
173	1.5	-2	12	101000100111
174	2	-1.5	12	101000101100
175	3.5	-1.5	12	101000110110
176	-0.5	-4	12	101000110111
177	-4	1	12	101000111000
178	0	-11.5	12	101000111010
179	0	9.5	12	101000111100
180	3.5	1.5	12	101000111101
181	0	8.5	12	101001010000
182	-9.5	-0.5	12	101001010011
183	-4	0.5	12	101001011011
184	-10	0	12	101001100010
185	-2.5	1.5	12	101001100100
186	-4.5	0.5	12	101001101010
187	6.5	-0.5	12	101001110111
188	-5.5	0.5	12	101001111000
189	4.5	0.5	12	101100000001
190	0.5	-4	12	101100000100
191	3	-1.5	12	101100000101
192	-2.5	-1.5	12	101100000110
193	-2	1.5	12	101100001000
194	2.5	1	12	101100011001
195	6.5	0.5	12	101100011101
196	-5.5	-0.5	12	101100011110
197	-2.5	1	12	101100011111
198	1	3	12	101100100001
199	0	-8.5	12	101100100010
200	0.5	-6.5	12	101100100011
201	-7.5	0	12	101100100100
202	3	-2	12	101100100101
203	-10.5	0	12	101100101000
204	6	-0.5	12	101100101010
205	5.5	-0.5	12	101100101101
206	3.5	-1	12	101100110100
207	-4.5	-0.5	12	101100110110
208	2	2	12	101100111001
209	0	-15	12	101100111010
210	1	-2.5	12	101100111100
211	0	-7	12	101100111101
212	2.5	1.5	12	101100111110
213	0	9	12	101100111111
214	11	0	12	101101000101

Index	Mv x	Mv y	Number of bits	Code
215	-1	2.5	12	101101000110
216	-14.5	-0.5	12	101101000111
217	4	-1	12	101101010101
218	0.5	-4.5	12	101101011001
219	-9.5	0.5	12	101101011010
220	10.5	0	12	101101011011
221	5.5	0.5	12	101101100010
222	9.5	-0.5	12	101101100011
223	0	14.5	12	101101100101
224	4.5	-0.5	12	101101101000
225	3.5	1	12	101101101100
226	7.5	0	12	101101101110
227	-0.5	-9.5	12	101101101111
228	-8	0	12	101101110011
229	2	1.5	12	101101111011
230	-1.5	-2.5	12	101110000110
231	-2	2	12	101110000111
232	4	-0.5	12	101110001011
233	1	-4	12	101110001110
234	15	0	12	101110001111
235	-0.5	5.5	12	101110010010
236	-12	0	12	101110010011
237	1.5	2	12	101110010100
238	8	0	12	101110010111
239	-0.5	-4.5	12	101111000010
240	-11	0	12	101111000100
241	0	-16	12	101111000101
242	4	0.5	12	101111000110
243	-14.5	0.5	12	101111000111
244	-1	-3.5	12	101111001011
245	-0.5	-5.5	12	101111001110
246	0	-7.5	12	101111001111
247	7	0	12	101111101000
248	5	-1	12	101111101100
249	1.5	-2.5	12	101111101101
250	14	0	12	101111101110
251	-3	-2	12	101111111000
252	-11.5	-0.5	12	101111111001
253	0	-10	12	101111111011
254	0	11.5	12	110000000110
255	-7	-0.5	12	110000010010
256	-0.5	6.5	12	110000010011
257	-15.5	15.5	12	110000100100
258	13.5	0	12	110000100101
259	-15.5	-0.5	12	110000101101
260	-0.5	4.5	12	110000101110
261	5	-0.5	12	110000101111
262	-5	-0.5	12	110000110101
263	0.5	5.5	12	110000110110
264	-14	0	12	110000110111
265	0	-11	12	110000111100
266	0.5	-5.5	12	110000111110
267	-5	1	12	110001000110
268	-6	-0.5	12	110001000111

Index	Mv x	Mv y	Number of bits	Code
269	8.5	-0.5	12	110001011000
270	-1.5	2	12	110001011001
271	1	-3.5	12	110001011010
272	-1.5	2.5	12	110001011111
273	15.5	-0.5	12	110100100010
274	-0.5	-14.5	12	110100100011
275	14.5	-0.5	12	110100100101
276	-15.5	-15.5	12	110100101010
277	0.5	6.5	12	110100101011
278	1	2.5	12	110100111000
279	-13.5	0	12	110100111100
280	-4	-1.5	12	110100111101
281	15.5	-15.5	12	110100111110
282	0	-8	12	110100111111
283	4	1	12	110101000111
284	0	15.5	12	110101010000
285	3	1.5	12	110101010101
286	-5	0.5	12	110101011011
287	-5	-1	12	110101011100
288	1.5	2.5	12	110101011101
289	-2	-3	12	110101110100
290	-15.5	0.5	12	110101110110
291	-3	-1.5	12	110101110111
292	0	-14	12	110101111000
293	-8.5	-0.5	12	110101111010
294	-0.5	4	12	110101111011
295	9.5	0.5	12	111010000010
296	2.5	-2	12	111010000111
297	14.5	0.5	12	111010001000
298	-0.5	-6	12	111010001110
299	0.5	4.5	12	111010001111
300	-0.5	-15.5	12	111010010000
301	0	-12	12	111010010001
302	11.5	-0.5	12	111010011100
303	10	0	12	111010110110
304	-4	-2	12	111010110111
305	-15	-0.5	12	111011110010
306	-0.5	-11.5	12	111011111010
307	-1.5	-3.5	12	111011111011
308	1.5	3.5	12	111100100001
309	0	8	12	111100100101
310	9	-0.5	12	111100111000
311	-0.5	6	12	111110001001
312	-0.5	8.5	12	111110010100
313	-12.5	0	12	111110010101
314	2	-3	12	111110010111
315	8.5	0.5	12	111110011100
316	-8.5	0.5	12	111110011101
317	1.5	-3.5	12	111110111001
318	0.5	-9.5	12	111111000000
319	-2	3	12	111111000001
320	0	10.5	12	111111000100
321	-1	3.5	12	111111000101
322	0	7.5	12	111111001101

Index	Mv x	Mv y	Number of bits	Code
323	-3.5	-2	12	111111010110
324	6	-1	12	111111010111
325	-0.5	9.5	12	111111011011
326	-1.5	3.5	12	111111100111
327	0	13.5	12	111111101010
328	-0.5	14.5	12	111111101011
329	-2.5	-2.5	12	111111110000
330	1	4	12	111111110001
331	0.5	-5	12	111111110010
332	-2.5	-2	12	111111110011
333	-6	0.5	12	111111111100
334	0.5	4	12	111111111101
335	5	0.5	12	111111111110
336	15.5	0.5	12	111111111111
337	15.5	15.5	13	1001010000000
338	-3.5	-3.5	13	1001010000001
339	1	-5	13	1001010000100
340	3	2	13	1001010000111
341	-2	-2.5	13	1001010001000
342	-1	4	13	1001010001001
343	0	-10.5	13	1001010001010
344	-3	1.5	13	1001010001011
345	-11.5	0.5	13	1001010001111
346	-0.5	-5	13	1001010010111
347	-1	-5	13	1001010110111
348	0.5	8.5	13	1001010111000
349	-10	-0.5	13	1001010111010
350	-12	-0.5	13	1001010111011
351	0.5	-14.5	13	1001010111100
352	2.5	-2.5	13	1001010111101
353	-7	-1	13	1010000010000
354	-4.5	1.5	13	1010000010011
355	12.5	0	13	1010000010111
356	-0.5	5	13	1010000011000
357	0.5	-6	13	1010000011001
358	2.5	2.5	13	1010000011111
359	3	3	13	1010000100110
360	0	11	13	1010000101000
361	0	-13.5	13	1010000101101
362	-3	-3	13	1010000101110
363	11.5	0.5	13	1010000101111
364	-9	-0.5	13	1010000111010
365	-4	1.5	13	1010000111011
366	2	3	13	1010001000011
367	4	-2	13	1010001001000
368	-2	-4	13	1010001001001
369	0	14	13	1010001001100
370	2.5	2	13	1010001100010
371	-1.5	-3	13	1010001101000
372	0.5	9.5	13	1010001101001
373	-4.5	-1.5	13	1010001101011
374	4.5	-1	13	1010001110010
375	1.5	-3	13	1010001110111
376	-15	-1	13	1010001111100

Index	Mv x	Mv y	Number of bits	Code
377	-0.5	-8.5	13	1010010010010
378	-0.5	11.5	13	1010010010011
379	0.5	-15.5	13	1010010100011
380	-4.5	-1	13	1010010101100
381	6	0.5	13	1010010110101
382	0	7	13	1010011000110
383	5	1	13	1010011001101
384	10.5	-0.5	13	1010011010000
385	-2.5	2.5	13	1010011010001
386	-4.5	1	13	1010011010010
387	1	3.5	13	1010011010011
388	3	-3	13	1010011010110
389	5.5	-1	13	1010011011111
390	8	-0.5	13	1010011101000
391	-10.5	-0.5	13	1010011101001
392	3.5	2.5	13	1010011101010
393	4.5	-1.5	13	1010011101011
394	3.5	-2	13	1011000000000
395	-16	-1	13	1011000000100
396	-7.5	-0.5	13	1011000000101
397	-10.5	0.5	13	1011000000110
398	-0.5	-7	13	1011000000111
399	2	-4	13	1011000001110
400	-6	-1	13	1011000001111
401	-2.5	2	13	1011000010010
402	0.5	14.5	13	1011000010011
403	-16	-0.5	13	1011000110000
404	-3	2	13	1011000110001
405	12	0	13	1011000111000
406	-3.5	2.5	13	1011000111001
407	1.5	4.5	13	1011001000000
408	2	-2.5	13	1011001000001
409	0.5	-11.5	13	1011001001100
410	15	-0.5	13	1011001001101
411	-3.5	-2.5	13	1011001001110
412	-5.5	-1	13	1011001001111
413	-1	5	13	1011001010010
414	0	-12.5	13	1011001010011
415	0.5	11.5	13	1011001010110
416	2	2.5	13	1011001010111
417	-1	-6	13	1011001011000
418	1.5	3	13	1011001011001
419	-11	-0.5	13	1011001100000
420	13	0	13	1011001100001
421	-5.5	1.5	13	1011001100010
422	-6	1	13	1011001100011
423	-0.5	-15	13	1011001101010
424	-3.5	3.5	13	1011001101011
425	-0.5	-16	13	1011001101110
426	4.5	1	13	1011001101111
427	-7.5	0.5	13	1011001110000
428	-0.5	-9	13	1011001110001
429	-10	-1	13	1011001110110
430	3	-4	13	1011001110111

Index	Mv x	Mv y	Number of bits	Code
431	4	-1.5	13	1011010001000
432	-1	-7	13	1011010001001
433	0.5	6	13	1011010101000
434	-13	0	13	1011010101001
435	11	-0.5	13	1011010110000
436	1	-6	13	1011010110001
437	14	-0.5	13	1011011000000
438	3.5	3.5	13	1011011000001
439	-0.5	-7.5	13	1011011000010
440	-14.5	-14.5	13	1011011000011
441	-0.5	9	13	1011011001000
442	-7	0.5	13	1011011001001
443	3.5	-3.5	13	1011011001100
444	-15.5	-1.5	13	1011011001101
445	-1	-4.5	13	1011011001110
446	-1.5	3	13	1011011001111
447	-4	3	13	1011011010010
448	-2	2.5	13	1011011010011
449	7.5	-0.5	13	1011011011010
450	3	-2.5	13	1011011011011
451	-2.5	-3.5	13	1011011100100
452	0.5	5	13	1011011100101
453	7	-0.5	13	1011011110100
454	-15	0.5	13	1011011110101
455	-14	-0.5	13	1011011111100
456	7.5	0.5	13	1011011111101
457	4.5	1.5	13	1011011111110
458	-3	3	13	1011011111111
459	-3	-2.5	13	1011100010000
460	-1.5	-4.5	13	1011100010001
461	-5.5	1	13	1011100010010
462	-4	2	13	1011100010011
463	1	-4.5	13	1011100010100
464	-14.5	14.5	13	1011100010101
465	-2	4	13	1011100011000
466	-12	-1	13	1011100011001
467	-0.5	15.5	13	1011100011010
468	-4	-3	13	1011100011011
469	2.5	-3	13	1011100101010
470	14.5	-14.5	13	1011100101011
471	-8	-0.5	13	1011100101100
472	9	-1	13	1011100101101
473	0	10	13	1011110000000
474	1	5	13	1011110000001
475	1.5	-4	13	1011110000010
476	-0.5	-10	13	1011110000011
477	0	15	13	1011110000110
478	-1	-5.5	13	1011110000111
479	5	-2	13	1011110010100
480	1.5	-4.5	13	1011110010101
481	-2	-3.5	13	1011111010010
482	3	-3.5	13	1011111010011
483	-1.5	4.5	13	1011111011110
484	3.5	-2.5	13	1011111011111

Index	Mv x	Mv y	Number of bits	Code
485	-5	-1.5	13	1011111110100
486	-1	4.5	13	1011111110101
487	-1	6	13	1100000001110
488	13.5	-0.5	13	1100000001111
489	-5	-2	13	1100000100000
490	9	0.5	13	1100000100001
491	-11	-1	13	1100000100010
492	1	4.5	13	1100000100011
493	-0.5	10.5	13	1100000101100
494	-5.5	-1.5	13	1100000101101
495	14	-1	13	1100000101110
496	-9	-1	13	1100000101111
497	-4	-4	13	1100001011000
498	2.5	-3.5	13	1100001011001
499	0.5	10.5	13	1100001101000
500	2.5	3.5	13	1100001101001
501	15.5	-1.5	13	1100001111010
502	5.5	-1.5	13	1100001111011
503	4	1.5	13	1100001111110
504	13.5	0.5	13	1100001111111
505	5.5	1	13	1100010110110
506	-3.5	2	13	1100010110111
507	3.5	2	13	1100010111100
508	-1.5	-4	13	1100010111101
509	10.5	0.5	13	1101001000000
510	-1.5	4	13	1101001000001
511	1	-5.5	13	1101001000010
512	-0.5	13.5	13	1101001000011
513	0.5	-8.5	13	1101001001000
514	-0.5	11	13	1101001001001
515	8	0.5	13	1101001001100
516	-0.5	-12	13	1101001001101
517	-0.5	8	13	1101001001110
518	-8	0.5	13	1101001001111
519	-0.5	-10.5	13	1101001010000
520	10	-0.5	13	1101001010001
521	-15.5	1.5	13	1101001010010
522	-13.5	0.5	13	1101001010011
523	-9.5	-3.5	13	1101001110010
524	0	12.5	13	1101001110011
525	-0.5	7.5	13	1101001110100
526	14.5	14.5	13	1101001110101
527	0.5	-7.5	13	1101001110110
528	0.5	-7	13	1101001110111
529	-0.5	-13.5	13	1101010001100
530	-4	-3.5	13	1101010001101
531	-1.5	-15.5	13	1101010100010
532	1	-7	13	1101010100011
533	-1	-15	13	1101010101000
534	-1.5	-5.5	13	1101010101001
535	12.5	-15.5	13	1101010110100
536	5	-1.5	13	1101010110101
537	8	-1	13	1101011101010
538	-3.5	-3	13	1101011101011

Index	Mv x	Mv y	Number of bits	Code
539	-6.5	-1	13	1101011110010
540	2.5	3	13	1101011110011
541	-3	-3.5	13	1110100000000
542	-13.5	-0.5	13	1110100000001
543	0.5	-10.5	13	1110100000010
544	-8	-1	13	1110100000011
545	-3	-4	13	1110100000110
546	-6.5	3.5	13	1110100000111
547	-16	0.5	13	1110100001100
548	-1	5.5	13	1110100001101
549	15.5	1.5	13	1110100010010
550	0.5	13.5	13	1110100010011
551	3.5	3	13	1110100111010
552	2	-3.5	13	1110100111011
553	-2.5	-3	13	1110101101000
554	3	2.5	13	1110101101001
555	-16	1	13	1110101101010
556	15	-1	13	1110101101011
557	4	2	13	1110111100000
558	10	-1	13	1110111100001
559	-2.5	3.5	13	1110111100010
560	-1	-10	13	1110111100011
561	0.5	15.5	13	1110111100110
562	-9	0.5	13	1110111100111
563	11	-1	13	1111001000000
564	-3.5	-9.5	13	1111001000001
565	-0.5	-11	13	1111001001000
566	3	4	13	1111001001001
567	7	0.5	13	1111001110010
568	-10	0.5	13	1111001110011
569	-3	2.5	13	1111100010000
570	7	-1	13	1111100010001
571	-6.5	-15.5	13	1111100011000
572	-3.5	3	13	1111100011001
573	-2	-5	13	1111100011010
574	-6	-1.5	13	1111100011011
575	0	-13	13	1111100101100
576	1.5	-5.5	13	1111100101101
577	-0.5	14	13	1111101110000
578	-6.5	-3.5	13	1111101110001
579	-15.5	-1	13	1111110011000
580	-12.5	-0.5	13	1111110011001
581	5	2	13	1111110110100
582	1.5	5.5	13	1111110110101
583	3	3.5	13	1111111000100
584	4	3	13	1111111000101
585	13	-0.5	13	1111111000110
586	-5	1.5	13	1111111000111
587	-1	-6.5	13	1111111001100
588	0	13	13	1111111001101
589	12.5	-0.5	13	1111111101100
590	15	-15.5	13	1111111101101
591	-0.5	-8	13	1111111101110
592	-14.5	-5.5	13	1111111101111

Index	Mv x	Mv y	Number of bits	Code
593	14.5	-5.5	14	10010100001010
594	-11.5	11.5	14	10010100001011
595	1.5	4	14	10010100001100
596	12.5	15.5	14	10010100001101
597	3.5	-4	14	10010100011100
598	0	12	14	10010100011101
599	-4	-2.5	14	10010100101100
600	-11.5	-11.5	14	10010100101101
601	2	-6	14	10010101100000
602	-1.5	15.5	14	10010101100001
603	-16	-2	14	10010101100010
604	4.5	-2.5	14	10010101100011
605	-15.5	3.5	14	10010101101100
606	-9.5	-1	14	10010101101101
607	-0.5	7	14	10010101110010
608	-14.5	4.5	14	10010101110011
609	5	-3	14	10010110110000
610	-3.5	-4.5	14	10010110110001
611	4	-4	14	10010110110010
612	0.5	-9	14	10010110110011
613	-15	-15	14	10100000100010
614	1	5.5	14	10100000100011
615	-14.5	-1	14	10100000100100
616	-15	-15.5	14	10100000100101
617	5.5	3.5	14	10100000101100
618	-5.5	-14.5	14	10100000101101
619	-1.5	5.5	14	10100000111000
620	-11	0.5	14	10100000111001
621	0.5	-13.5	14	10100000111010
622	-12.5	0.5	14	10100000111011
623	-0.5	-14	14	10100000111100
624	15	0.5	14	10100000111101
625	-6	-3	14	10100001001110
626	4.5	-2	14	10100001001111
627	-4	2.5	14	10100001010010
628	-14.5	5.5	14	10100001010011
629	14.5	4.5	14	10100001011000
630	5.5	1.5	14	10100001011001
631	-15	-5	14	10100010000000
632	0.5	-10	14	10100010000001
633	-2	-6	14	10100010000010
634	-1	9	14	10100010000011
635	13.5	-15.5	14	10100010000100
636	-9.5	-9.5	14	10100010000101
637	-15.5	8.5	14	10100010011010
638	-14	-1	14	10100010011011
639	10	0.5	14	10100010110100
640	2	-5	14	10100010110101
641	15.5	-6.5	14	10100010110110
642	2	4	14	10100010110111
643	-1	-12	14	10100011000000
644	0.5	7.5	14	10100011000001
645	0.5	-16	14	10100011000010
646	-14.5	10.5	14	10100011000011

Index	Mv x	Mv y	Number of bits	Code
647	6.5	-3.5	14	10100011000110
648	-1.5	5	14	10100011000111
649	1	6	14	10100011010100
650	-0.5	15	14	10100011010101
651	6.5	-1	14	10100011100110
652	11.5	11.5	14	10100011100111
653	-14.5	-15.5	14	10100011101100
654	9.5	-9.5	14	10100011101101
655	-2	3.5	14	10100011111010
656	15.5	-14.5	14	10100011111011
657	0.5	-15	14	10100011111100
658	0.5	-8	14	10100011111101
659	14.5	-15.5	14	10100011111110
660	6	3	14	10100011111111
661	-6	-2	14	10100100100000
662	11	0.5	14	10100100100001
663	-4.5	2.5	14	10100100100010
664	0.5	8	14	10100100100011
665	-5.5	3.5	14	10100101000100
666	11.5	-11.5	14	10100101000101
667	13.5	-14.5	14	10100101001000
668	6.5	-15.5	14	10100101001001
669	-14.5	9.5	14	10100101001010
670	6.5	3.5	14	10100101001011
671	15.5	-11.5	14	10100101011010
672	-5	-4	14	10100101011011
673	5	1.5	14	10100101011100
674	3	-5	14	10100101011101
675	-1	-15.5	14	10100101011110
676	-9.5	3	14	10100101011111
677	4.5	2.5	14	10100101101000
678	-6.5	2.5	14	10100101101001
679	1.5	-5	14	10100110001110
680	15.5	-4.5	14	10100110001111
681	-15.5	14.5	14	10100110010100
682	-3.5	-4	14	10100110010101
683	-15	1	14	10100110010110
684	2	5	14	10100110010111
685	3.5	8.5	14	10100110011000
686	-5	3	14	10100110011001
687	-11.5	-3.5	14	10100110011100
688	-9	-3	14	10100110011101
689	-6	2	14	10100110011110
690	1.5	6.5	14	10100110011111
691	-14.5	-10.5	14	10100110101110
692	5.5	-3.5	14	10100110101111
693	-12.5	-15.5	14	10100110111000
694	-4.5	-3.5	14	10100110111001
695	-4.5	-2.5	14	10100110111010
696	-9.5	3.5	14	10100110111011
697	-14.5	15.5	14	10100110111100
698	9.5	8.5	14	10100110111101
699	6.5	2.5	14	10100111011000
700	-1.5	-6.5	14	10100111011001

Index	Mv x	Mv y	Number of bits	Code
701	-10	-3	14	10100111011010
702	-11.5	3.5	14	10100111011011
703	-2.5	3	14	10100111100100
704	-2	5	14	10100111100101
705	-5.5	-3.5	14	10100111100110
706	9.5	3.5	14	10100111100111
707	1.5	-15.5	14	10110000000010
708	6	1	14	10110000000011
709	Esc	Esc	4	1000

Brief Overview of a Computer System

Figure 7 and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the invention may be implemented. Although the invention or aspects of it may be implemented in a hardware device, the encoder and decoder described above are implemented in computer-executable instructions organized in program modules. The program modules include the routines, programs, objects, components, and data structures that perform the tasks and implement the data types described above.

While Fig. 7 shows a typical configuration of a desktop computer, the invention may be implemented in other computer system configurations, including hand-held devices, multiprocessor systems, microprocessor-based or programmable consumer electronics, minicomputers, mainframe computers, and the like. The invention may also be used in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

Figure 7 illustrates an example of a computer system that serves as an operating environment for the invention. The computer system includes a personal computer 720, including a processing unit 721, a system memory 722, and a system bus 723 that interconnects various system components including the system memory to the processing unit 721. The system bus may comprise any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using a bus architecture such as PCI, VESA, Microchannel (MCA), ISA and EISA, to name a few. The system memory includes read only memory (ROM) 724 and random access memory (RAM) 725. A basic input/output system 726 (BIOS), containing the basic routines that help to transfer information between elements within the personal computer 720, such as during start-up, is stored in ROM 724. The personal computer 720 further includes a hard disk drive 727, a magnetic disk drive 728, e.g., to read from or write to a removable disk 729, and an optical disk drive

730, e.g., for reading a CD-ROM disk 731 or to read from or write to other optical media. The hard disk drive 727, magnetic disk drive 728, and optical disk drive 730 are connected to the system bus 723 by a hard disk drive interface 732, a magnetic disk drive interface 733, and an optical drive interface 734, respectively. The drives and their associated computer-readable media provide nonvolatile storage of data, data structures, computer-executable instructions (program code such as dynamic link libraries, and executable files), etc. for the personal computer 720. Although the description of computer-readable media above refers to a hard disk, a removable magnetic disk and a CD, it can also include other types of media that are readable by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, and the like.

A number of program modules may be stored in the drives and RAM 725, including an operating system 735, one or more application programs 736, other program modules 737, and program data 738. A user may enter commands and information into the personal computer 720 through a keyboard 740 and pointing device, such as a mouse 742. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit 721 through a serial port interface 746 that is coupled to the system bus, but may be connected by other interfaces, such as a parallel port, game port or a universal serial bus (USB). A monitor 747 or other type of display device is also connected to the system bus 723 via an interface, such as a display controller or video adapter 748. In addition to the monitor, personal computers typically include other peripheral output devices (not shown), such as speakers and printers.

The personal computer 720 may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer 749. The remote computer 749 may be a server, a router, a peer device or other common network node, and typically includes many or all of the elements described relative to the personal computer 720, although only a memory storage device 750 has been illustrated in Figure 7. The logical connections depicted in Figure 7 include a local area network (LAN) 751 and a wide area network (WAN) 752. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets and the Internet.

When used in a LAN networking environment, the personal computer 720 is connected to the local network 751 through a network interface or adapter 753. When used in a WAN networking environment, the personal computer 720 typically includes a modem 754 or other means for establishing communications over the wide

area network 752, such as the Internet. The modem 754, which may be internal or external, is connected to the system bus 723 via the serial port interface 746. In a networked environment, program modules depicted relative to the personal computer 720, or portions thereof, may be stored in the remote memory storage device. The network connections shown are merely examples and other means of establishing a communications link between the computers may be used.

Conclusion

While the invention has been illustrated using a specific implementation as an example, the scope of the invention is not limited to the specific implementation described above. Spatial prediction effectively exploits the spatial dependency of motion vectors and improves the efficiency of jointly coding motion vectors with a single entropy code. However, the specific form of prediction used on the motion vectors is not critical to the invention. In fact, it is possible to implement the invention without using a prediction scheme.

The implementation described above specifically uses a Huffman coding scheme to compute entropy codes for a joint motion vector parameter. As noted, it is also possible to use other forms of entropy coding to encode the joint parameter with a single entropy code.

In view of the many possible implementations of the invention, it should be recognized that the implementation described above is only examples of the invention and should not be taken as a limitation on the scope of the invention. Rather, the scope of the invention is defined by the following claims. We therefore claim as our invention all that comes within the scope and spirit of these claims.

We claim:

1. In a video coder for coding video images in a block format, a method for improving compression of the video images comprising:

predicting x and y motion vector components for a current block of pixels based on a motion vector of at least one neighboring block of pixels to compute x and y components of a predictor motion vector;

computing differential x and y components from the x and y components of the predictor and x and y components of a motion vector for the current block; and

assigning a single variable length code to joint x and y differential motion vector components, such that shorter variable length codes are assigned to joint differential motion vector components that have a higher probability of occurrence in the video images, and longer variable length codes are assigned to joint differential motion vector components that have a lower probability of occurrence.

2. The method of claim 1 wherein the variable length codes are assigned from a variable length code table comprising a list of pairs of joint differential motion vector components and a corresponding variable length code for each pair of joint differential motion vector components.

3. The method of claim 2 wherein the assigning step includes:

looking up the joint differential motion vector components in the table;

when no match is found in the table, coding an escape code along with a fixed length code for each differential motion vector component.

4. The method of claim 1 wherein the block of pixels corresponds to a macroblock in a video frame divided into fixed-sized, rectangular macroblocks, and the predicting computing, and assigning steps are repeated for the macroblocks in the video frame.

5. The method of claim 1 wherein the block of pixels corresponds to a macroblock of a video object plane in video frame having two more video object planes, and the video object planes are each divided into fixed-sized, rectangular macroblocks; and

the predicting, computing and assigning steps are repeated for the macroblocks in the video object planes.

6. A computer readable medium having instructions for performing the steps of claim 1.

7. In a video decoder, a method for decoding macroblocks of a predicted video frame comprising:

receiving a single variable length code representing joint x and y components of a motion vector for each of the macroblocks;

for each of the macroblocks, searching for a single entry in an entropy codebook corresponding to the variable length code and including the x and y components of the motion vector; and

using the x and y components of the motion vector from the codebook to define motion of pixels in a corresponding macroblock.

8. The method of claim 7 wherein the x and y components of the motion vector in the codebook comprise x and y differential motion vector components, and the method comprises:

reconstructing the motion vector from the differential motion vector components and x and y components of a predictor motion vector.

9. The method of claim 7 wherein the codebook is a Huffman table trained for a target bit rate and content type from a statistical analysis of example video sequences having the content type.

10. A computer readable medium having instructions for performing the steps of claim 7.

11. A motion vector encoder comprising:

a motion vector predictor for computing a motion vector predictor for a motion vector of a block of pixels from at least one motion vector for a neighboring block of pixels;

a subtractor for computing differential motion vector components from motion vector components of the predictor and the motion vector of the block of pixels; and

a joint entropy coder for jointly coding the differential motion vector components with a single variable length code.

12. The encoder of claim 11 wherein the joint entropy coder computes the single variable length code by searching for the code in a Huffman coding table

comprising a list of joint differential motion vectors and a corresponding variable length code for each of the joint differential motion vectors.

13. A motion vector decoder comprising:

a motion vector predictor for computing a motion vector predictor for a motion vector of a block of pixels from at least one motion vector for a neighboring block of pixels;

a joint entropy decoder for decoding a single variable length code into joint differential motion vector components; and

an adder for reconstructing X and Y motion vector components from the joint differential motion vector components and X and Y components of the motion vector predictor.

14. The decoder of claim 13 wherein the joint entropy decoder decodes the single variable length code by searching for the code in a Huffman coding table comprising a list of variable length codes and corresponding joint differential motion vector components for each the variable length codes.

15. The decoder of claim 13 wherein the joint entropy decoder is operable to detect an escape code indicating that two fixed length codes representing X and Y differential motion vector components follow the escape code.

16. In a video coder for coding video images in a block format, a method for improving compression of the video images comprising:

computing x and y motion vector components for a block;

forming the x and y motion vector components into a joint parameter representing joint x and y motion vector components; and

assigning a single variable length code to the joint x and y motion vector components, such that shorter variable length codes are assigned to joint motion vector components that have a higher probability of occurrence in the video images, and longer variable length codes are assigned to joint differential motion vector components that have a lower probability of occurrence.

17. The method of claim 16 further including spatially predicting the x and y motion vector components from a neighboring block of the block; and using spatially predicted components as the joint x and y motion vector components.

18. The method of claim 17 wherein the spatially predicted components are differential motion vector components computed as a difference between x and y components of the motion vector for the block and x and y components of a predictor motion vector.

19. In a video decoder, a method for decoding macroblocks of a predicted video frame comprising:

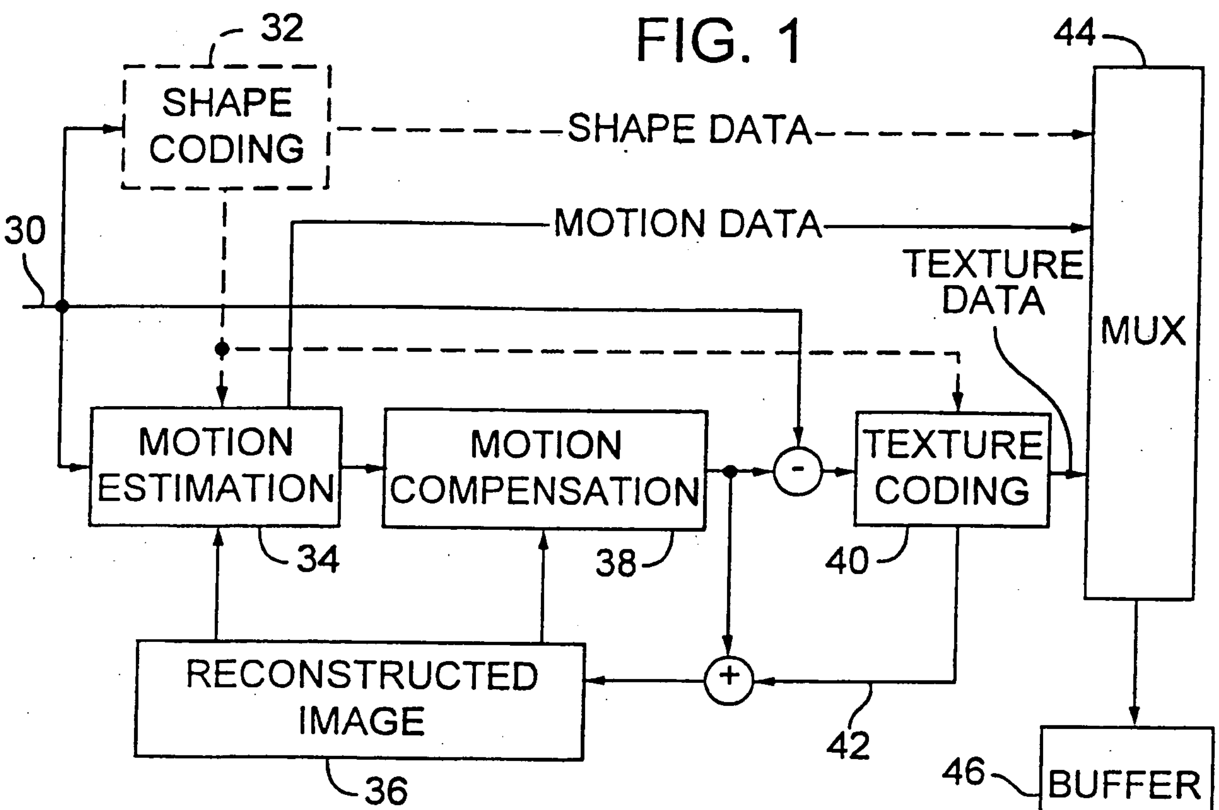
receiving a single variable length code representing joint differential x and y components of a motion vector for each of the macroblocks;

for each of the macroblocks, searching for a single entry in a Huffman table corresponding to the variable length code and including the joint differential x and y components of the motion vector;

computing x and y components of a predictor motion vector from neighboring macroblocks to the macroblock currently being decoded; and

reconstructing the motion vector from the differential components obtained from the Huffman table and the x and y components of the predictor motion vector.

FIG. 1


32
SHAPE CODING
SHAPE DATA
MOTION DATA
30
TEXTURE DATA
44
MUX
MOTION ESTIMATION
MOTION COMPENSATION
TEXTURE CODING
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38
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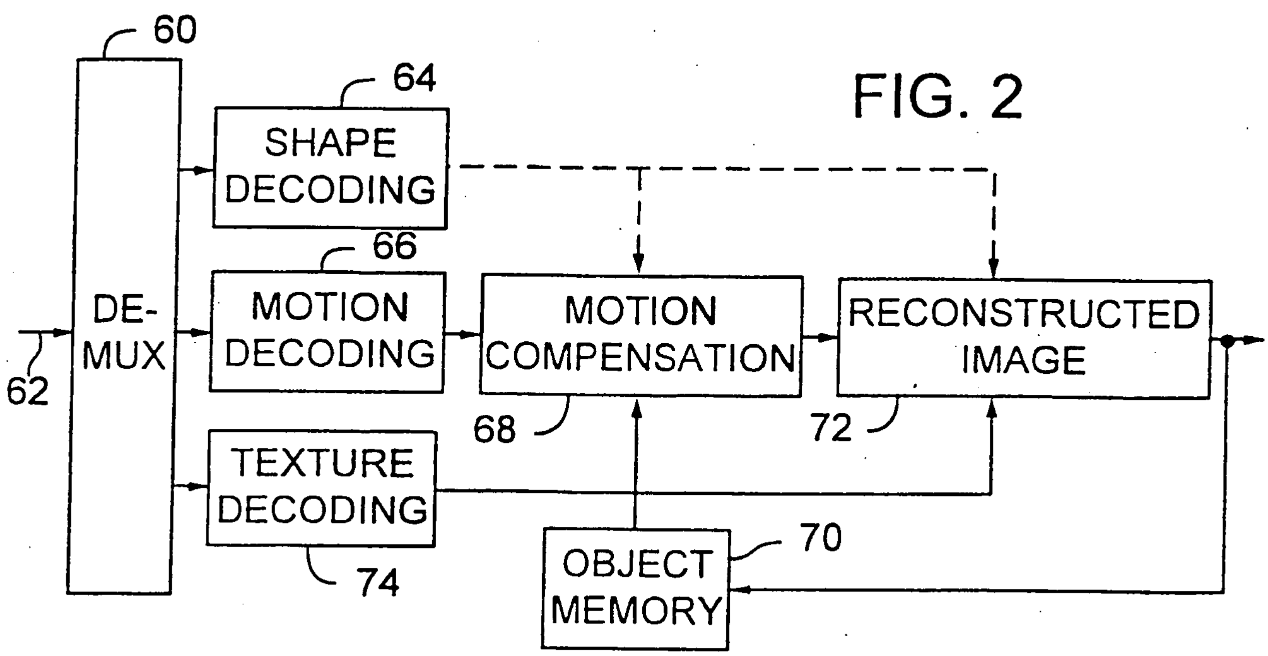
RECONSTRUCTED IMAGE
42
36
46
BUFFER

FIG. 2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64
SHAPE DECODING
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MOTION DECODING
MOTION COMPENSATION
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62
68
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TEXTURE DECODING
70
OBJECT MEMORY
74

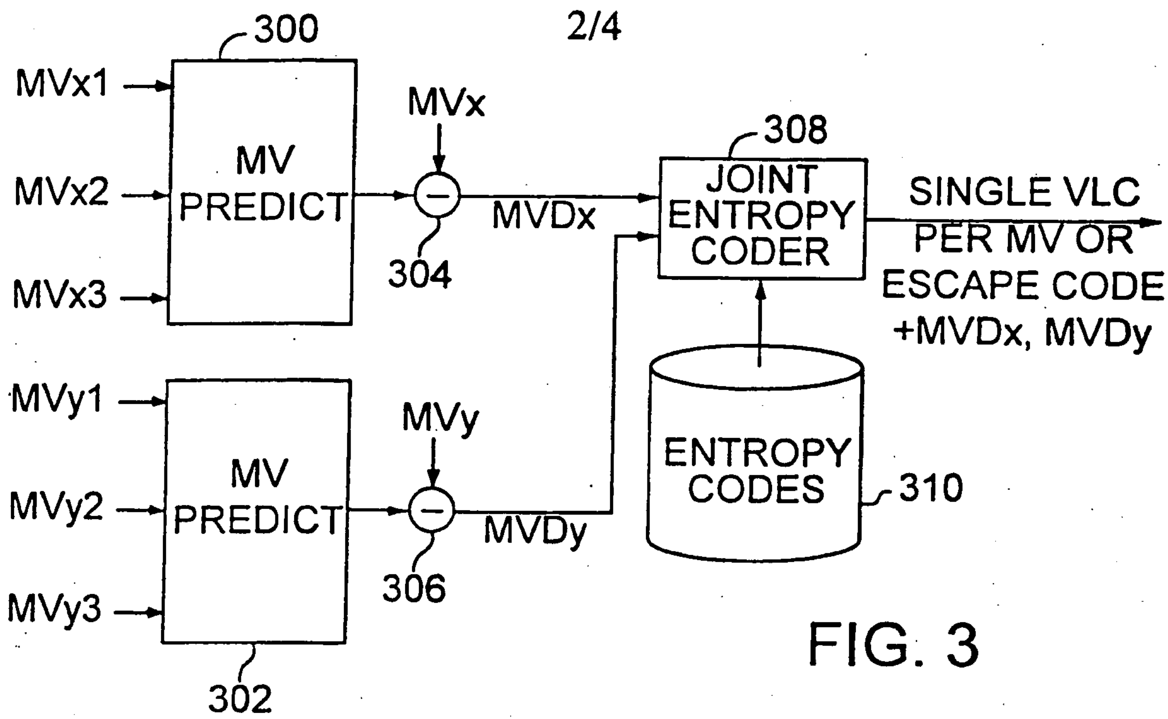


FIG. 3

FIG. 4

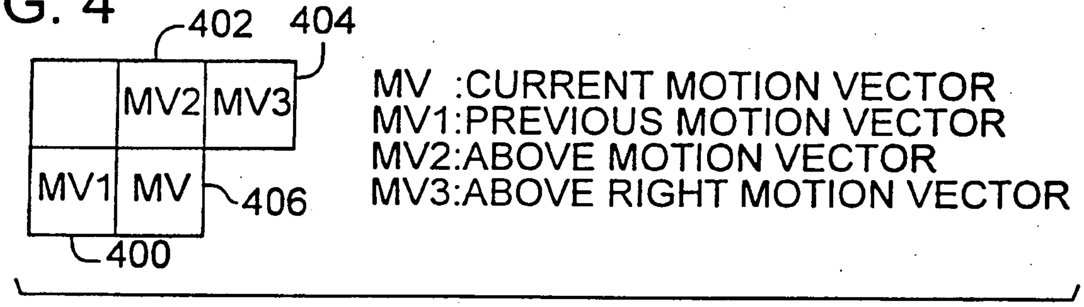


FIG. 5

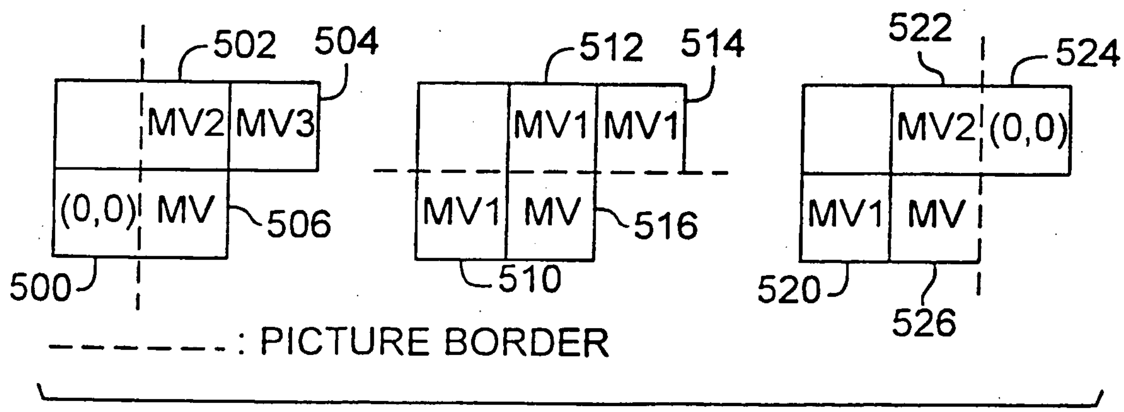


FIG. 6

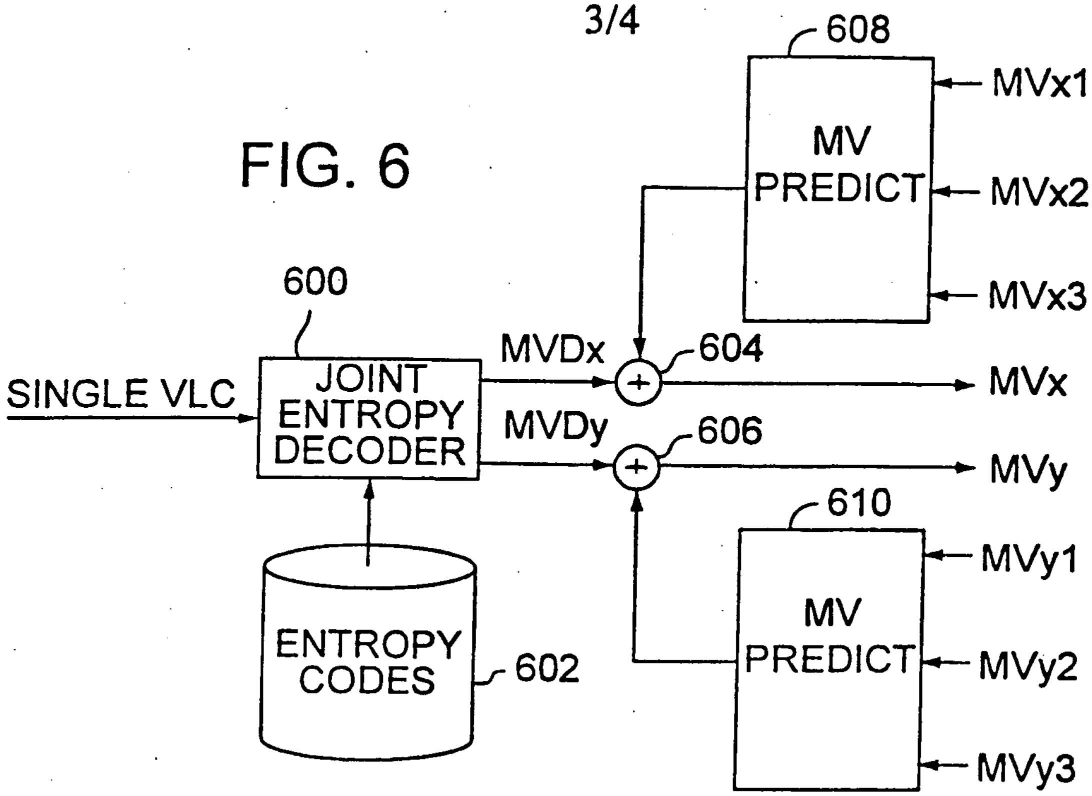
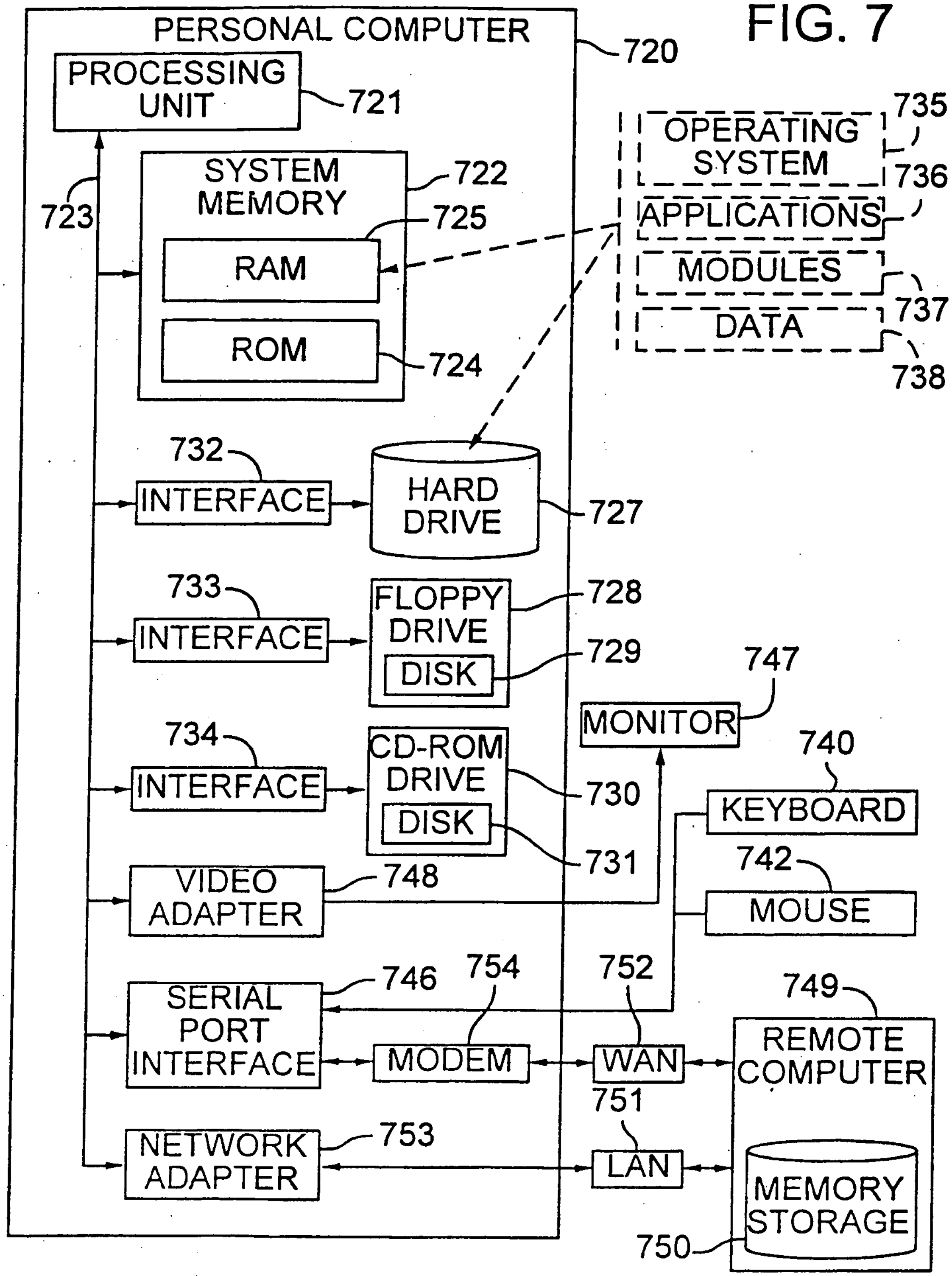

SINGLE VLC
600
JOINT ENTROPY DECODER
ENTROPY CODES
602
MVDx
MVDy
604
606
MVx
MVy
608
MV PREDICT
MVx1
MVx2
MVx3
610
MV PREDICT
MVy1
MVy2
MVy3

FIG. 7


PERSONAL COMPUTER
720
PROCESSING UNIT
721
SYSTEM MEMORY
722
723
RAM
725
ROM
724
OPERATING SYSTEM
735
APPLICATIONS
736
MODULES
737
DATA
738
732
INTERFACE
HARD DRIVE
727
733
INTERFACE
FLOPPY DRIVE
728
DISK
729
734
INTERFACE
CD-ROM DRIVE
730
DISK
731
MONITOR
747
KEYBOARD
740
VIDEO ADAPTER
748
MOUSE
742
SERIAL PORT INTERFACE
746
754
MODEM
752
WAN
749
REMOTE COMPUTER
751
NETWORK ADAPTER
753
LAN
MEMORY STORAGE
750

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 99/28395

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GUO YAO YU ET AL: "TWO-DIMENSIONAL MOTION VECTOR CODING FOR LOW BITRATE VIDEOPHONE APPLICATIONS" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING. (ICIP),US,LOS ALAMITOS, IEEE COMP. SOC. PRESS,1995, pages 414-417, XP000572969 ISBN: 0-7803-3122-2 paragraph '0002!	1-19

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 March 2000	03/04/2000

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	AD HOC GROUP ON MPEG-4 VIDEO VM EDITING: "MPEG-4 Video Verification Model Version 7.0 Chapter 3: Encoder Definition" INTERNATIONAL ORGANIZATION FOR STANDARDIZATION - ORGANISATION INTERNATIONALE DE NORMALISATION,XX,XX, 1 April 1997 (1997-04-01), pages 1,17-122, XP002084924 paragraph '3.3.3.7!	1-19
A	US 5 428 396 A (KATO MOTOKI ET AL) 27 June 1995 (1995-06-27) abstract	1-19

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/28395

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